Technical Support Document for Chloride Total Maximum Daily Load Analysis Calleguas Creek Watershed

March 22, 2002

US EPA Region 9
California Regional Water Quality Control Board
Los Angeles Region

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1. EXECUTIVE SUMMARY

This document provides details of technical analyses conducted in developing the Total Maximum Daily Load (TMDL) for chloride in the Calleguas Creek watershed (USEPA Region 9 2002a). This technical support document describes specific types of analyses, which are necessary to support decisions that have been incorporated into the TMDL. The analyses in this document include: identifying, quantifying, and characterizing current conditions and loads (based on best available information); identifying and selecting critical conditions for protection of water quality in the waterbody; estimating quantitative linkage between current loads and water quality conditions in the waterbody, using a mass balance model for linkage analysis; estimating quantitative effects of changing loads on future conditions in the waterbody, using the same model applied for the linkage analysis; and establishing WLAs and LAs that will fully support the beneficial uses of the waterbody and remove impairment for chloride in the watershed.

Loads of chloride impairing Calleguas Creek enter the waterbody through three major types of activities or natural processes: municipal wastewater effluent from publicly owned treatment works (POTWs); discharge to the surface water from groundwater; and runoff from various urban and agricultural land uses. Analyses throughout this document make quantitative estimates of the total mass from each load using the best available information. Estimated daily loads for the three types are summarized in Table 1, calculated as an annual average. In addition, the table shows the load from storm water runoff. That is a substantial chloride load to the waterbody, estimated on an annual average at about 35,000 lb/day, but does not cause impairment because storm flow is much greater than average daily flow and chloride is diluted such that it does not affect beneficial uses.

Table 1. Summary of total chloride loads to Calleguas Creek and tributaries.

Type of load	Chloride load to entire watershed (annual average), lb/day
POTWs	21,200
Groundwater discharges	7,310
Miscellaneous land use runoff	7,200
Stormwater runoff (not an impairment)	35,000

The ultimate sources of chloride to POTW discharges are domestic residential activities and chloride in source water provided for municipal use. The ultimate sources of chloride to the groundwater are activities in the watershed that either generate or concentrate chloride, which enters the groundwater and may, in some locations and under some conditions, enter surface waters. Activities responsible for the largest part of loads to groundwater include: septic systems; two POTWs that discharge to percolation ponds near the stream channel; and possibly shallow soils and rocky substrates that are relatively rich in chlorides. Agricultural activities also contribute chloride to groundwater, by concentrating chloride already present in delivered irrigation water. Agricultural irrigation is not considered a source of chloride to the waterbody or to the groundwater, because the agricultural activities themselves do not add chloride. They do, however, concentrate chloride delivered to groundwater. The ultimate sources of chloride in miscellaneous land use runoff include urban runoff (lawn watering, building and sidewalk washing, etc.), accounting for about 90% of this load; and agricultural tail water, discharged in a few locations where tile drains convey tail water directly to the waterbody.

The WLAs proposed in this document are used in the TMDL to allocate chloride loads to dischargers in the watershed. The allocation is designed to achieve specified numeric targets for chloride concentration that will eliminate the impairment in each reach of Calleguas Creek and its tributaries. WQOs are specified for each reach of the waterbody, and were selected to protect the designated beneficial use in each reach. Agricultural irrigation is the most sensitive beneficial use in all reaches of Calleguas Creek where that use is designated or present, and groundwater recharge is the most sensitive in other impaired reaches, especially where groundwater is used for agricultural water supply. The existing WQO for concentration of chloride is 150 mg/L for Reaches 3 through 13.

A linkage analysis relates observed in-stream conditions with measured or estimated loads. The loads are location-specific, and affect chloride concentrations in specific reaches of the watershed in complex interrelationships. The linkage analysis is based on reasonable interpretations of the best data currently available. The linkage was evaluated using a mass balance model with best available data and simplifying assumptions about chloride origins and transport. The model uses reasonable assumptions where data conflicted or were incomplete, and where chloride origin and transport were uncertain. The data, assumptions, and model structure were verified by comparing model outputs to measured in-stream flows and concentrations for an approximate match.

The linkage model was then used to develop WLAs and LAs that are calculated to achieve the numeric target for each reach. Loads to each reach are calculated according to the reach’s assimilative capacity, or its ability to dilute chloride, which depends on both the total flow available and the chloride concentration in that flow. The model was adapted to incorporate anticipated changes to hydrology from a planned diversion in Conejo Creek. The diversion will withdraw water for agricultural irrigation in the Santa Rosa Valley, reducing available assimilative capacity in the waterbody. The WLAs and LAs were calculated using a margin of safety of 10%, by reserving an unallocated assimilative capacity of 10% of the total load, to compensate for uncertainties in the estimated loads and model relationships. The WLAs for major sources and minor sources are summarized in Tables 2a, 2b and 3. The WLAs and LAs are calculated for two types of critical conditions, or conditions when chloride concentration is expected to be at its maximum and to contribute to the maximum impairment for chloride in this waterbody. The two are described with the terms “routine critical conditions” and “drought critical conditions.”

The standard routine critical condition is defined by maximum non-storm flow, or the highest volume flow in the waterbody that does not originate with stormwater runoff. That critical period is used to calculate the WLAs and LAs for everyday discharges because it can be shown that the critical conditions may occur at any time during a typical year. The maximum non-storm flow is chosen as the critical condition rather than the lowest flow, which is the most critical period for many other waterbodies for many pollutants. The maximum non-storm flow is a critical flow for impairment by chloride in Calleguas Creek, because chloride load from various non-point sources such as groundwater have their greatest impact during those conditions.

The long-term critical condition is drought, including the period immediately following a drought. Groundwater discharges are an important factor in making those conditions critical, as they are in the routine critical conditions. Chloride in groundwater of the Calleguas Creek watershed is strongly affected by human activities, primarily the agricultural concentrating effect, described in Section 5 of this document. Groundwater chloride concentration may be expected to increase during a drought, when less rainwater enters the aquifers to dilute chloride mass already present. An additional factor is that during a drought, imported water used in the watershed is typically higher in chloride. That change in imported water supply increases chloride load in POTW discharges, and also exacerbates the effect of concentrating chloride in agricultural fields. Local supplies of drinking and irrigation water are stressed due to the drought, therefore, the volume of imported water with elevated level of chloride may also increase. The most critical effects of the drought appear to occur in the immediate post-drought period. After the drought ends, as rainfall increases, the water table rises and natural discharges to the waterbody resume, carrying increased chloride load. Available water quality data support the conclusion that drought periods increase the chloride impairment of the waterbody. Surface water concentration increased following the 1989-1991 drought: in 1992, the average of all concentration measurements was greater than 220 mg/L, compared to averages in the range of 150 to 180 mg/L in the 1980s. The TMDL analyses use the post-drought period to define the drought critical condition.

The technical analyses define a drought period, for purposes of this TMDL, as follows. WLAs for drought conditions are specified to begin on June 1 of a year when the total rainfall of the previous twelve months has been less than 11.0 inches, measured at the Camarillo Airport, which is the lower 15% of the historical range for rainfall for the Calleguas Creek watershed. The drought period is defined to end on June 1 of a year when the total rainfall of the previous twelve months measured at the Camarillo Airport has been greater than 12.2 inches, which is the lower 25% of the historical range. During that period the drought-condition WLAs will be in effect for all major and minor dischargers to the waterbody. That definition uses local meteorological conditions, and is derived from the statewide operational definition specified by the California Department of Water Resources. Details of the definition and the rationale for its adoption are supplied in Section 8B2.

Table 2a. WLAs and LAs under Routine Conditions[#]

Discharge	Discharge Target Concentration (mg/L)	WLA (lb/day)	LA (lb/day)
Tapo Canyon, Reach 8			
Groundwater discharge	160		640
Urban non-storm runoff	130		500
Arroyo Simi, Reach 7			
Groundwater discharge, headwaters	160		640
Urban non-storm runoff	100		400
Pumped groundwater	142	1,400	
Groundwater discharge, near Simi Valley	150		1,600
Simi Valley POTW	134	10,100	
Arroyo Las Posas, Reach 6			
Moorpark POTW	136	2,200	
Conejo Creek South Fork, Reach 13*			
Groundwater discharge	160		1,300
Pumped Groundwater	136	360	
Urban non-storm runoff	160		2,600
Conejo Creek North Fork, Reach 12			
Groundwater discharge	150		2,400
Urban non-storm runoff	150		1,600
Arroyo Santa Rosa, Reach 11			
Groundwater discharge	130		2,100
Urban non-storm runoff	100		800
Conejo Creek Hill Canyon, Reach 10			
Hill Canyon POTW	125	10,100	
Conejo Creek main stem, Reach 9B			
Groundwater discharge	130		1,400
Sub-Surface inflow	136		720
Urban non-storm runoff	100		430
Conejo Creek main stem, below diversion, Reach 9A			
Groundwater discharge	150		1,600
Camarillo POTW	133	2,300	
Calleguas Creek Main Stem, Reach 3			
Groundwater discharge near Conejo confluence	136		1,100
Agricultural discharge	136		1,300
Camrosa POTW	136	1,500	
Groundwater discharge near Camrosa POTW	136		1,500
TMDL		28,000	22,000

[#] Routine condition applies on any day not influenced by either storm flow or drought conditions.

* See Table 10.

Table 2b. WLAs and LAs under Drought Condition[#]

Discharge	**Discharge Target Concentration (mg/L)**	**WLA (lb/day)**	**LA (lb/day)**
Tapo Canyon, Reach 8			
Groundwater discharge	192		800
Urban non-storm runoff	130		500
Arroyo Simi, Reach 7			
Groundwater discharge, headwaters	192		800
Urban non-storm runoff	100		400
Pumped groundwater	107	1,200	
Groundwater discharge, near Simi Valley	180		1,900
Simi Valley POTW	129	9,200	
Arroyo Las Posas, Reach 6			
Moorpark POTW	100	1,600	
Conejo Creek South Fork, Reach 13*			
Groundwater discharge	192		1,500
Pumped Groundwater	124	330	
Urban non-storm runoff	160		2,600
Conejo Creek North Fork, Reach 12			
Groundwater discharge	180		2,880
Urban non-storm runoff	150		1,600
Arroyo Santa Rosa, Reach 11			
Groundwater discharge	156		2,500
Urban non-storm runoff	100		800
Conejo Creek Hill Canyon, Reach 10			
Hill Canyon POTW	124	9,700	
Conejo Creek main stem, Reach 9B			
Groundwater discharge	156		1,700
Sub-Surface inflow	136		730
Urban non-storm runoff	100		430
Conejo Creek main stem, below diversion, Reach 9A			
Groundwater discharge	136		1,400
Camarillo POTW	136	2,200	
Calleguas Creek Main Stem, Reach 3			
Groundwater discharge near Conejo confluence	136		1,000
Agricultural discharge	136		1,300
Camrosa POTW	136	1,500	
Groundwater discharge near Camrosa POTW	136		1,500
TOTAL ALLOCATION		26,000	24,000

[#] Drought condition applies during drought and immediately after drought, with conditions as defined in the text.
* See Table 10.

Table 3. WLAs for Pumped Groundwater Discharges in Reach 13*

Discharger	Flow, ft^3/s	Load, lb/day* for Routine Condition @ 136 mg/L Cl	Load, lb/day* for Drought Condition @ 124 mg/L Cl
Northrop	0.017	12	11
Rockwell (Tonexant)	0.033	24	22
Teleflex	0.15	110	100
Al-sal	0.056	41	37
Chevron	0.067	49	45
Chevron	0.067	49	45
Emery	0.00046	0.33	0.30
ARCO	0.017	12	11
Mobil	0.017	12	11
Mobil	0.067	49	45

** Flow information based on current NPDES permit.*

2. INTRODUCTION

This document presents calculations and technical background for the Total Maximum Daily Load (TMDL) for chloride in the Calleguas Creek watershed. Calleguas Creek is a river system in Ventura County, California with substantial long-established agricultural use; substantial and rapidly growing urban and suburban development; and portions that remain in a relatively natural state. The system is typical of smaller watersheds in coastal southern California, with peak flows originating as runoff from discrete wet-season storm events that exceed baseline flow by one to two orders of magnitude. Flows at other times are produced by wastewater discharges and, in some parts of the system, groundwater discharged from shallow surface aquifers or by pumping for construction dewatering or remediation of contaminated aquifers. Patches of high quality riparian habitat are present along the length of the river and its tributaries.

Beneficial uses in the Calleguas Creek watershed have been determined to be impaired by the presence of chlorides. In particular, presence of chloride under current conditions impairs the agricultural beneficial use in many parts of the watershed, and the groundwater recharge beneficial use in some parts of the watershed.

2A. ORGANIZATION OF THIS DOCUMENT; TMDL ELEMENTS ADDRESSED

This document is designed to provide technical information to stakeholders, the public, and regulatory decision-makers on certain elements of the TMDL for chloride in the Calleguas Creek watershed. This document addresses the following elements:

- Analysis of existing conditions, including seasonality and critical conditions, with a description of rationale for selecting critical conditions for the TMDL so that

WQOs may be expected with reasonable assurance to be attained under all conditions;

- Identification and quantification of sources of chloride in the waterbody;
- Calculation of the maximum pollutant load consistent with protecting beneficial uses of the waterbody, including a numeric target for each reach that is designed to protect each reach's beneficial uses;
- Analysis of the linkage of the pollutant load to observed ambient conditions in the waterbody; and
- Allocations among the watershed's dischargers of waste loads and loads that would reduce pollutant loads to the maximum allowable load, or less (a margin of safety and consideration of foreseeable pollutant load increases due to population growth and other changes.

The analyses in this document take a reach-by-reach approach which constitute a finer sub-division of the waterbody than is currently defined in the Water Quality Control Plan, Los Angeles Region (CRWQCB-LA, 1994), referred to hereinafter as the Basin Plan. In a separate action, the Regional Board has proposed that the Basin Plan be amended to incorporate the finer sub-division of reaches as described in this document and the companion proposed chloride TMDL for Calleguas Creek. The new reach sub-division allows analysis of beneficial uses in more detail, more specific to local conditions, than the current Basin Plan reach designations.

3. PROBLEM IDENTIFICATION

This section describes the reaches of the waterbody; the overall structure of the waterbody and the watershed, with typical flow patterns and interrelationships among reaches and land uses; and the existing beneficial uses in each reach.

3A. REACHES OF CALLEGUAS CREEK AND TRIBUTARIES

Historically, the number and location of reaches used to describe the Calleguas Creek system has evolved as various regulatory agencies have developed water quality standards and watershed definitions. The 1994 Basin Plan (CRWQCB-LA, 1994) used two reaches for Calleguas Creek and its tributaries. In order to better capture the variation in flow conditions, beneficial uses, and stream characteristics, EPA is using the proposed reach re-designation by the Regional Board. The proposed redefinition consists of 14 reaches, described in Table 4 and mapped in Figure 1.

3B. WATERSHED DESCRIPTION, REACH CONNECTIONS AND FLOW RELATIONSHIPS

The watershed encompasses about 343 square miles in Ventura County in an area with a decades-long history of agricultural production and recent trends of rapidly growing population. Flow patterns and existing conditions in the system are discussed in this section. The watershed map in Figure 2 shows the location of major sources of flow, including POTWs, approximate groundwater discharge regions, and regions of urban development where urban non-storm runoff may originate. The map also shows approximate regions of groundwater recharge, where water leaves the waterbody and enters the underlying aquifers.

The watershed has three general areas: a northern portion, the Arroyo Las Posas/Arroyo Simi system and its tributaries (Reaches 6, 7 and 8); a southern portion, Conejo Creek and its tributaries (Reaches 9A, 9B, 10, 11, 12, and 13); and a main stem, to which both other systems are themselves tributaries (Reach 3). This section describes the typical conditions within the key reaches, and the ways in which water moves into and among reaches of the watershed under non-storm conditions.

Table 4. Reaches of Calleguas Creek Watershed: Beneficial Uses, Brief Description, and WQOs

Proposed Reach No.	Reach Name	Geographic Description	Notes: Hydrology, land uses, etc.	1994 *Basin Plan* Chloride WQO (mg/L)
1*	Mugu Lagoon	Lagoon fed by Calleguas Creek	Estuarine; brackish, contiguous with Pacific Ocean.	No reach-specific objective
2*	Calleguas Creek South	Downstream (south) of Potrero Rd.	Tidal influence; impermeable layer; tile drains; Oxnard Plain groundwater basin contains both unconfined, perched aquifers.	No reach-specific objective
3	Calleguas Creek North	Potrero Rd. upstream to confluence Conejo Creek	No tidal influence. Surface water designated beneficial uses include existing AGR and GWR. Agricultural tile drains. Pleasant Valley Groundwater Basin includes confined (impermeable layer) and unconfined perched aquifers. Both are designated as existing AGR beneficial use. Camrosa WWRF discharges to percolation ponds, and to surface waters during high rainfall overflows.	150
4*	Revolon Slough	Revolon Slough from Mugu Lagoon to Central Ave	Surface water designated beneficial uses include existing AGR and GWR. Agricultural tile drains present. Concrete lined between Central Ave. and Wood Rd; from there the slough is soft-bottomed with rip-rapped sides. The lower mile and a half of the slough appear to be tidally influence. Pleasant Valley Groundwater Basin includes confined (impermeable layer) and unconfined perched aquifers. Both are designated as existing AGR.	150
5*	Beardsley Channel (Wash)	Revolon Slough upstream of Central Ave	Surface water is not designated for AGR or GWR beneficial uses. Channel lined with rip-rap. Drains from hills north from the City of Camarillo to Revolon Slough. Agricultural tile drains present.	150
6	Arroyo Las Posas	Confluence with Calleguas Creek to Hitch Road	Surface water designated as potential AGR and existing GWR for surface water; normally dry at Calleguas confluence except during storm events. Las Posas Groundwater Basin designated as AGR. Ventura Co. WWTP discharges to percolation ponds at Moorpark; west from Hitch Road. Important avocado growing region.	150

Table 4, Continued. Reaches of Calleguas Creek Watershed: Beneficial Uses, Brief Description, and WQOs

Proposed Reach No.	**Reach Name**	**Geographic Description**	**Notes: Hydrology, land uses, etc.**	**1994 *Basin Plan* Chloride WQO (mg/L)**
7	Arroyo Simi	End of Arroyo Las Posas (Hitch Rd) to headwaters in Simi Valley	Surface water designated intermittent GWR, no AGR designation for surface water but flows downstream to Arroyo Las Posas, which has potential AGR and existing GWR. Simi Valley Water Quality Control Facility discharges to surface water. Simi Valley groundwater basin includes both confined and unconfined aquifers. Both are designated as AGR; pumped groundwater and shallow groundwater discharges to surface water. Avocado production present in the lower segments of this reach; tributary to an important avacado growing region.	150
8	Tapo Canyon (including Gillibrand Canyon)	Confluence with Arroyo Simi up Tapo Canyon to headwaters	Surface water designated intermittent GWR beneficial use in Gillibrand Canyon Creek and potential AGR beneficial use in Tapo Canyon Creek; tributary to Arroyo Simi and Arroyo Las Posas, where AGR and GWR reuses are designated. Gillibrand Groundwater Basin designated as AGR. Tributary to an important avocado growing region.	150
9A	Conejo Creek	Extends from Camrosa Diversion to confluence with Calleguas Creek	Surface water designated as existing AGR and GWR. Camarillo WWTP discharges to surface water. Pleasant Valley Groundwater Basin contains both confined and unconfined perched aquifers. Both designated AGR. Limited cultivation of chloride-sensitive crops.	150
9B	Conejo Creek	Extends from the confluence with Arroyo Santa Rosa downstream to the Camrosa Diversion	Surface water designated as existing AGR and GWR. Pleasant Valley Groundwater Basin contains both confined and unconfined perched aquifers. Both designated as AGR. Limited cultivation of chloride-sensitive crops.	150

Table 4, Concluded. Reaches of Calleguas Creek Watershed: Beneficial Uses, Brief Description and WQOs

Proposed Reach No.	**Reach Name**	**Geographic Description**	**Notes: Hydrology, land uses, etc.**	**1994 *Basin Plan* Chloride WQO (mg/L)**
11	Arroyo Santa Rosa	Confluence w/ Conejo Creek to headwaters	Surface water designated as intermittent GWR. Olsen Rd WRP to be decommissioned and influent diverted to Hill Canyon WWTF, dry before Calleguas Ck confluence except during storm flow. Arroyo Santa Rosa groundwater basin designated as AGR. Limited cultivation of chloride-sensitive crops.	150
12	North Fork Conejo Creek	Confluence w/Conejo Creek to headwaters	Surface water designated as existing AGR and GWR; currently exceeds chloride WQO (>150 mg/L). Groundwater designated as AGR; currently exceeds chloride WQO (> 150 mg/L). Limited cultivation of chloride-sensitive crops.	150
13	Arroyo Conejo (South Fork Conejo Creek)	Confluence w/ N. Fork to headwaters—two channels	Surface water designated as intermittent GWR. GW exceeds WQO (>150 mg/L); City of Thousand Oaks; pumped/treated GW. Limited cultivation of chloride-sensitive crops.	150

* Reaches not included in the scope of this TMDL.

Figure 1. Map of the Calleguas Creek Watershed, with Gauging Stations and Proposed Reaches, May 2001

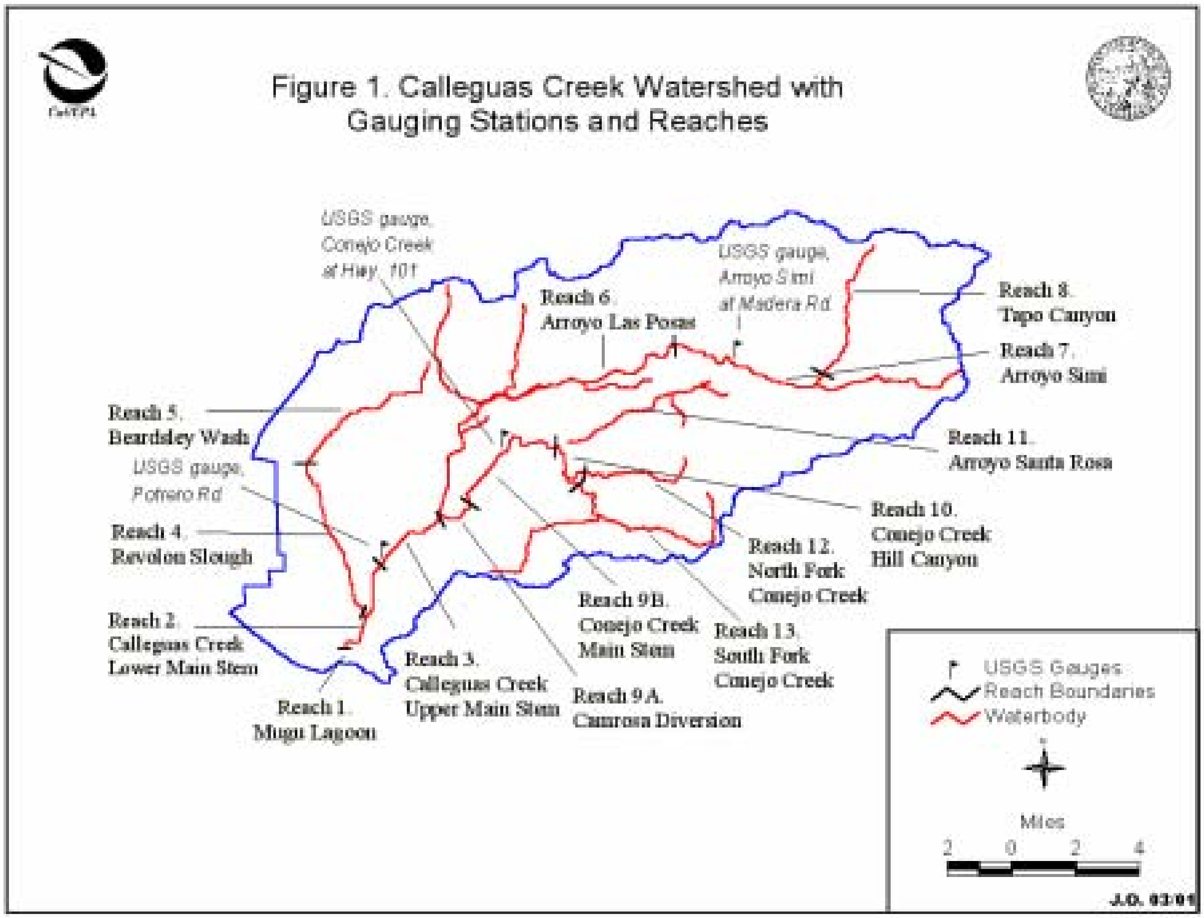
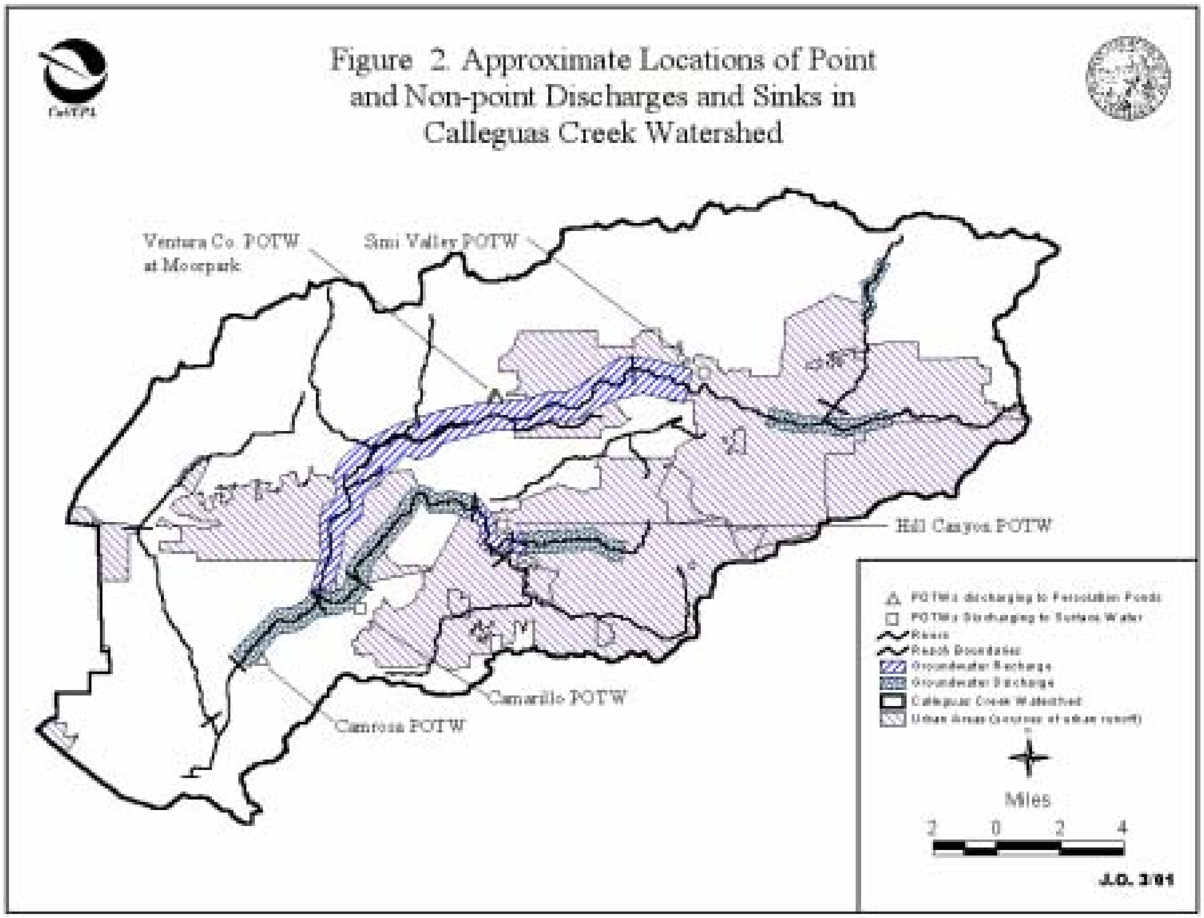


Figure 2. Map of the Calleguas Creek Watershed with Major Inflows and Outflows, Including Areas of Urban Runoff, Groundwater Discharge, and Groundwater Recharge.



3B1. Northern Tributary System (Reaches 6, 7 and 8)

The northern part of the watershed system originates in the Simi Valley and surrounding foothills, with headwaters at the Santa Susanna pass (Reach 7) and Tapo Canyon (Reach 8). Substantial urban land uses are found in the northern watershed in the city of Simi Valley, covering the upper half of Reach 7 and the downstream portion of Reach 8 to the Reach 7 confluence; and the city of Moorpark, which lies across the downstream end of Reach 7 and the upstream end of Reach 6. In the Simi basin, the groundwater table is high, discharging to the stream under most conditions. Some groundwater is pumped for dewatering, and discharged under permit to the stream. A POTW, the Simi Valley WQCP, discharges treated municipal wastewater in Reach 7 below the Reach 8 confluence.

Reach 6 receives surface flow from Reach 7. In Reach 6, surface flow diminishes under typical non-storm conditions. Much of the water is withdrawn for agricultural irrigation, especially in the upstream half of the reach. In the upstream portion of the reach, a system of shallow and perched aquifers above the deeper aquifer is in close communication with surface flow, receiving recharge from the stream channel and discharging in some locations. Water is also withdrawn from these aquifers by pumps and through shallow spring-boxes in and near the channel.

The POTW at Moorpark (Ventura County WWTP, also called Moorpark WWTP) affects these aquifers. The Moorpark treated municipal wastewater is discharged into a percolation basins facility adjacent to the stream channel, where it enters the shallow aquifers of the waterbody. Agricultural uses of water generate the agricultural concentrating effect in this area, as described in Section 5B below. The shallow groundwater has increased in chloride concentration, as discussed in Section 4B below.

In the downstream half of Reach 6, during the dry weather season, typically any remaining flow goes to recharge groundwater. The Pleasant Valley aquifer underlying downstream Reach 6 has been in overdraft in recent decades, so recharge capacity is substantial, and exceeds the available in-stream flow except during wet-season storm discharge. Typically Arroyo Las Posas is dry just downstream of the Ventura County WWTP at Moorpark, at a location that varies by season and by year. The stream bed enters the Calleguas Creek main stem, Reach 3, but there is no surface flow except during storm discharge.

3B2. Southern Tributary System (Reaches 9A, 9B, 10, 11, 12 and 13)

Conejo Creek drains the southern portion of the watershed. This area supports significant residential land uses, especially in the Thousand Oaks area drained by the South Fork of Conejo Creek. The area also supports significant agricultural land uses, especially in the Santa Rosa Valley area, downstream of the confluence of the North and South Forks and including the area drained by the Arroyo Santa Rosa. During non-storm periods, flow in Conejo Creek is dominated by discharges of treated municipal wastewater. Upstream of the wastewater discharges, pumped groundwater and urban non-storm runoff sustain a small baseline flow.

The headwaters of the southern area are in the North Fork and South Fork of Conejo Creek, Reaches 12 and 13 respectively. Under non-storm conditions, water originates from two processes: discharge of groundwater in springs, and overland flow of domestic water across the urban landscape of Thousand Oaks. The North Fork drains the open space of Wildwood Park and the adjacent urban land uses, and the South Fork drains a larger area primarily consisting of urban and suburban land uses. Under current conditions typical flow from Reaches 12 and 13 combined is about half as great as typical daily discharge from the larger POTWs in the watershed. Water quality of this flow is relatively poor, with as much as 165 mg/L chloride. The North Fork and South Fork converge in Reach 10, Hill Canyon reach of Conejo Creek. In this reach, the flow is greatly increased by permitted discharges from the Hill Canyon WWTF. In Reach 10, Conejo Creek descends through open space and a relatively shallow groundwater basin.

At the downstream end of Reach 10, Conejo Creek enters the Santa Rosa Valley and empties into Reach 9B. Reach 11 (Arroyo Santa Rosa), a tributary, joins from the north, draining the upstream portion of the Santa Rosa Valley. Arroyo Santa Rosa is ephemeral, considered to often be dry, but on many occasions is observed to flow with about 1 ft^3/s even during the dry weather season and other non-storm conditions. Sources of this flow are believed to be urban land uses in the Reach 11 drainage, and some groundwater discharge in the upstream portions. The Olsen Road POTW lies in the Santa Rosa basin and has historically increased the surface flow, but has been decommissioned. The influent to the Olsen Road POTW is expected to be rerouted to the Hill Canyon WWTF, increasing flows from that POTW by a relatively small proportion. This document calculates flows as if that rerouting had already occurred.

In Reaches 9A and 9B, the creek is augmented by groundwater discharges from the shallow aquifer system, as well as by urban non-storm runoff and subsurface flows from Reaches 10 and 11. In this area is the Ventura County Agricultural Preserve, an area of agricultural land use. Water is withdrawn for irrigation from Conejo Creek or from the closely-associated shallow aquifers. Downstream from the Santa Rosa Valley, Reach 9A, the surface flow receives treated municipal wastewater discharged by the Camarillo WWTP. Some flow is lost to groundwater recharge in this area.

3B3. Calleguas Creek Main Stem and Oxnard Plain (Reaches 1, 2, 3, 4 and 5)

Downstream of the confluence of the northern and southern reaches lies the Oxnard Plain, drained by shallow tributaries (Reaches 4 and 5) and the Calleguas Creek main stem (Reaches 2 and 3). The Oxnard Plain is the site of intensive agricultural land use, primarily irrigated by pumping from deep local aquifers.

The southern and northern tributary systems join to form the Calleguas Creek main stem in the vicinity of the City of Camarillo. Conejo Creek enters the Calleguas Creek main stem, Reach 3, at the downstream end of Reach 9A. The northern tributaries enter the from Arroyo Las Posas, Reach 6, which is dry except during storm discharge, as described above. In Reach 3, the surface flow is separated from deep underlying aquifers by shallow clayey layers, interspersed with perched shallow groundwater aquifers. The local shallow groundwater is observed to be high in chloride concentrations, reaching 200 mg/L and more. In this reach is the Camrosa WWRF, which discharges through a percolation facility into the shallow groundwater system.

At Reach 2, the channel enters the estuarine part of the system. Discharge from Reach 2 then enters Mugu Lagoon, defined as Reach 1, and then flows into the Pacific Ocean. Mugu Lagoon supports a diverse wildlife population including migratory and endangered species, and is not considered impaired for chloride because the wildlife present depends on the varying salinity produced by estuarine conditions. Inputs of chloride from the Calleguas Creek system are not found to have substantial effects on this normal salinity fluctuation. The area of Reach 1 is affected by military land uses of the Pt. Mugu Naval Air Weapons Station and substantial agricultural activities in the Oxnard Plain. Reaches 4 and 5, Revolon Slough and Beardsley Channel respectively, flow directly into the estuary in Reach 2. These two reaches are not tributary to the main system of Calleguas Creek, and have not been listed impaired for chloride. For those reasons, none of the estuarine reaches (Reaches 1, 2, 4, and 5) are addressed in this document.

3C. DESIGNATED AND OBSERVED BENEFICIAL USES AND ASSOCIATED IMPAIRMENT

The beneficial uses for the reaches in Calleguas Creek watershed addressed in the TMDL are those identified in the Basin Plan (CRWQCB-LA, 1994). A full description of each of these beneficial uses is included in the Basin Plan; a summary appears in the TMDL document. Among these defined beneficial uses, two are impaired by chlorides under current conditions: agricultural use, in most or all of the reaches where the beneficial use currently exists; and groundwater recharge, in some of the reaches where the beneficial use currently exists. Other beneficial uses are not believed to be currently impaired by chloride, and are not expected to be negatively impacted by the changes specified in this TMDL.

3C1. Groundwater Recharge Beneficial Use Impairment

The groundwater recharge (GWR) beneficial use is defined by the Basin Plan (CRWQCB, 1994) as "uses of water for natural or artificial recharge of ground water for purposes of future extraction, maintenance of water quality, or halting of saltwater intrusion into freshwater aquifers." For the Calleguas Creek watershed, an existing or potential groundwater recharge beneficial use is listed for all reaches included in this TMDL. In some areas the recharge enters deep aquifers, and in other areas the recharge enters shallow or perched aquifers. Both kinds of aquifers are heavily used in various parts of the watershed.

The deeper aquifers of the North Las Posas, Pleasant Valley, and Oxnard Forebay basins show increasing chloride concentration over recent decades (RWQCB database, 1957-present), as discussed in Section 4B below. Chloride concentration in some wells, during some periods, routinely exceed the WQO of 150 mg/L for the beneficial use to which the groundwater is applied. This implies the groundwater recharge beneficial use for in-stream surface water is impaired under current conditions. The deep aquifers do not discharge to surface waters unless water is pumped, because the water table is well below the surface contours. Those aquifers have been reported to be in overdraft since at least the 1960s (USGS, 1980; Bookman-Edmonston Engineering, Inc., 1998).

Groundwater quality conditions are further described in Section 4B below. To summarize, the RWQCB database contains results for 45 groundwater samples taken in the Calleguas Creek watershed from 1989 to 1999. Eight exceeded the 150 mg/L limit, and four are an order of magnitude higher. Many samples exceeded the limit for the specific groundwater basin in which they were collected. The high concentrations of chloride observed in groundwater are evidence that the beneficial use of groundwater recharge is not being protected under current conditions.

The shallow aquifers are of particular interest because their water is in close connection with surface waters. Protecting groundwater recharge in reaches with extensive shallow aquifers also helps protect the agricultural beneficial use for surface water, which is impaired as described below. Shallow aquifers located upstream of the Simi Valley and Hill Canyon POTWs discharge to the surface without pumping, in varying amounts depending on the depth of the water table. In some reaches the shallow aquifers are heavily used, primarily for agricultural irrigation. In some of these same reaches, withdrawals for beneficial uses are in close proximity to discharges to the stream, some of which contain high chloride loads, and some portions of which go immediately to recharge groundwater. Water in the shallow aquifers is pumped or collected for agricultural supply water in several locations, including: Arroyo Las Posas (immediately downstream of the Ventura County POTW); Conejo Creek downstream of the Hill Canyon POTW; Arroyo Santa Rosa; and the Calleguas Creek main stem in the Oxnard Plain. In some parts of Arroyo Las Posas, groundwater is collected by springboxes within the stream channel and applied for agricultural irrigation. The springboxes are porous containers sunk just below the surface of the dry stream bed, which fill with water in sufficient amounts to allow pumping. Protecting the groundwater recharge beneficial use is especially critical in areas where the shallow groundwater is withdrawn for beneficial uses in close proximity to the recharge areas. As described in Section 3C2 below, the agricultural beneficial use is impaired in many of these areas.

The shallow groundwater in many of the Calleguas Creek reaches is in direct hydrological connection with the surface water; it is chemically and physically similar or identical to the surface water; and there is comparatively little physical separation between the surface and groundwater at any time or place. Therefore the appropriate WQOs should be selected considering the beneficial use not to be groundwater recharge, but the beneficial uses of the aquifers. In Calleguas Creek the most sensitive beneficial use of the aquifers is agricultural irrigation. In areas where the shallow groundwater is pumped and used for agriculture, it is appropriate to protect the groundwater recharge beneficial use at the same WQO as the agricultural beneficial use for which the recharging sources are immediately applied, so long as that WQO is within the general guidance supported by the Basin Plan. Therefore impairment of the recharge beneficial use may be described as identical with impairment of the agricultural use in reaches where the shallow groundwater is immediately pumped for agricultural irrigation. That impairment is described in Section 3C2 below.

3C2. Agricultural Beneficial Use Impairment

The agricultural beneficial use (AGR) is defined by the Basin Plan (CRWQCB, 1994) as "uses of water for farming, horticulture, or ranching including, but not limited to, irrigation, stock watering, or support of vegetation for range grazing." For the Calleguas Creek watershed, an existing or potential agricultural supply water beneficial use is listed for Calleguas Creek, southernmost Conejo Creek and Arroyo Las Posas, as shown in Table 4 above. Agricultural beneficial uses were also identified in Arroyo Santa Rosa. The quality of the agricultural supply water in the Calleguas Creek watershed has diminished with economic implications for growers, especially in certain areas.

In the Arroyo Las Posas area, the decline in quality of the shallow aquifers strongly affects a productive agricultural region largely served by the Zone Mutual Water Company. Zone Mutual pumps water from 30 foot wells adjacent to the river, drawing from the shallow and perched aquifers described above. The company reports that nursery customers have stopped purchasing the water due to decreased quality, and that other growers who use the water have made adjustments that affect their economic viability. Reported adjustments include switching to more chloride-tolerant crops even if they are less profitable, finding alternative sources of income (i.e. abandoning agricultural production), and selling their land. Some of these changes may be attributed to decreasing water quality, including increased chloride. (Zone Mutual Water District, 1990).

3C3. Other Beneficial Uses

Other beneficial uses are not impaired at present, and the recommended changes in objectives will not affect other beneficial uses. Ambient conditions in freshwater reaches of the watershed are within the tolerance of freshwater aquatic life and human health. Human health is not affected by current ambient conditions, and conditions rarely exceed the aesthetic standard of 250 mg/L. This TMDL will not result in increased concentration of chlorides in those reaches, and the reduced concentrations anticipated are not detrimental to any other beneficial uses. Two types of endangered and rare species known to use the watershed: pinnepeds, saltwater mammals limited to Mugu Lagoon, where the reduced chloride loads resulting from this TMDL will not appreciably affect ambient conditions; and the Clapper Rail, a bird that uses both Mugu Lagoon and freshwater reaches of Calleguas Creek, so therefore is known to be tolerant of saline conditions.

4. EXISTING WATER QUALITY CONDITIONS

Flow throughout the waterbody is a dynamic system, influenced by multiple factors in ways that are not fully understood or precisely predictable. Factors that affect the flow in a given reach at a given time may include: soil conditions; capacity of the shallow aquifers; location and geometry of underlying impermeable clay layers; depth to bedrock or other impermeable surfaces; volume of precipitation in a season or in a given storm event; location and timing of surface water withdrawals and pumping from the aquifers; and others. Many of these factors also affect chloride mass and concentration in the surface waters and in the near-surface aquifers.

Some reaches support recharge of deep aquifers with large storage capacity, where the recharge is more or less a steady state and reasonably predictable. Other reaches are associated with shallow or perched aquifers, separated from deeper soils and aquifers by impermeable clay layers. Water in those aquifers is in close communication with surface water of those reaches. In some reaches groundwater discharges to produce surface flow, then downstream is absorbed into the aquifers, and may travel along the stream as subsurface flow from which it may discharge again to appear as surface flow. Sometimes the flow appears in increased quantities and sometimes in diminished quantities.

For these reasons, there is considerable uncertainty in the flow in a given reach under "typical" conditions, and mathematical descriptions of those conditions are not precise. Estimates of flow are necessary for this TMDL's analyses of sources, linkage of sources to in-stream conditions, and waste loads that will allow unimpaired beneficial uses in each reach. The simplified description attempted here of reach characteristics, flow within and between reaches, and water quality within reaches is an approximation. Critical conditions are identified and described to the extent possible, but current data are not sufficient to predict flows or chloride concentrations under all conditions.

4A. SURFACE WATER QUALITY CONDITIONS

The TMDL (USEPA Region 9 2002a) summarizes the following chloride concentration data from the Regional Board database and other studies.

The Regional Board database includes chloride concentration measurements for various locations in the waterbody. The data set for the northern tributaries, (Arroyo Las Posas/Arroyo Simi) reaches extends from 1951 to 1997. The period from 1951 through 1974 consisted of 43 samples. The average chloride concentration was 112 mg/L, with a standard deviation of 179 mg/L. Eight samples, or 19%, exceeded the average. The data set for the period from 1975 through 1986 consisted of 17 samples. The average chloride concentration for this period was 109 mg/L, with a standard deviation of 96 mg/L. In this data set, 53% of the samples exceeded the average. The average concentration during the most recent period, from 1987 through 1997, rose to 194 mg/L, with a standard deviation of 190 mg/L; 13% of the 30 samples exceeded the average.

The data set reviewed for the southern tributaries (Conejo Creek and its tributaries) extended from 1951 through 1997, with approximately 30 samples taken from 1951 through 1974, 56 during the period from 1974 through 1986, and 167 from 1986 through 1997. The data set shows an increasing trend in the chloride concentrations in Conejo Creek beginning with an average chloride concentration of about 80 mg/L for the period prior to 1975, rising to 116 mg/L for the period of from 1975 through 1986, and to 179 mg/L from 1986 through 1987. During the period from 1975 through 1986, only one sample exceeded the WQO of 150 mg/L. In the period from 1987 through 1997, 75% of the samples exceeded the existing WQO of 150 mg/L. The Calleguas Creek Characterization Study or CCCS (LWA, 2000) measured chloride concentration 10 to 12 times at each of 29 sites throughout the watershed from July 1998 through June 1999. Results of the CCCS for some key locations are summarized in the TMDL (USEPA Region 9 2002a).

In summary, Regional Board staff's review of available surface water data found substantial increasing trend in chloride concentrations since 1975. In addition the 1998 303(d) listings of waterbodies impaired for chloride, which was based on a WQO of 150 mg/L, was confirmed.

The chloride concentration data are sufficient to demonstrate an increase from the 1950s to the 1990s, but the data are not sufficiently extensive to identify causal relationships between in-stream concentration and a wide range of factors potentially influencing conditions. Physical or environmental factors that could cause variation include rainfall by season, depth to the water table at a given time, or proximity of a particular stream reach to a potential chloride source. Further, the variation may be influenced by a number of human-influenced factors such as variation in wastewater discharges from POTWs, amount of groundwater pumped for construction dewatering or soil remediation, the location and depth from which that groundwater is pumped, usage of domestic water softeners, changes in crop type, or changes in total acreage planted. Minor changes in one or more factors might produce significant concentration changes in a waterbody where typical flow volume is so small relative to observed variations and to known discharges. Incidental, irregular discharges may originate with a wide range of source activities, and the water quality of those discharges is widely variable and not well known. The linkage between sources and in-stream conditions is likely to be affected by varying time lags in varying connections of shallow aquifers to surface water.

Data are sufficient to demonstrate the impact of one factor: total annual rainfall, in particular years of low rainfall producing drought conditions. Surface water concentration was higher following the 1989-1991 drought: the average of all concentration measurements was greater than 220 mg/L in 1992. The strong influence of drought years suggests the importance of groundwater discharge on surface water concentration in the watershed; low rainfall during the drought is unlikely to directly increase chloride concentrations one year later, but groundwater concentration may be expected to increase as less rainwater enters the aquifers to dilute chlorides already present that re-circulate owing to the agricultural concentrating effect (described below in Section 5B2).

4B. GROUNDWATER QUALITY CONDITIONS

Groundwater in the basin has been extensively used since about the 1920s, when the dominant regional agricultural production changed from cattle ranching to orchard and field crops. Deep confined aquifers (the Fox Canyon, Modelo Formation, and Grimes Canyon aquifers) underlie most of the basin, from Simi Valley westward to the Pacific Ocean, including the Arroyo Santa Rosa area but not extending south (CMWD/MWDSC, 1989; USGS, 1980).

In the deepest groundwater basins, groundwater levels have generally declined, especially in the downstream parts of the watershed, attributable to overdraft pumping for agricultural and domestic water supply from the deeper aquifers of the North Las Posas, Santa Rosa and Conejo basins. These were noted to be in overdraft before the 1960s (USGS, 1980, CMWD/MWD SC, 1989). In the North Las Posas basin the storage capacity made available by the declining water table has been used to store imported water. In the shallower aquifers, in most locations, water levels began to rise in the 1980s due to the importation of water to the watershed.

A number of shallow unconfined aquifers of quaternary age underlie parts of the basins, including the Simi Valley; downstream areas of Arroyo Las Posas; the Arroyo Santa Rosa; and the area drained by Conejo Creek and its tributaries. The perched shallow aquifers have been heavily utilized since the advent of irrigated agriculture, and remain so under present conditions. That shallow system is contiguous with the stream system, and surface water appears to be in close communication with water in the aquifers. That is, in at least some locations, the shallow groundwater and surface water freely intermingle, rising to the surface at some times or locations and disappearing into the sediments at other times or locations, in essence forming a single waterbody. In other locations, and at other times, the interchange is slower or occurs across an intervening layer of soils or sediments. Close communication between groundwater and surface water is taken to mean that, in many parts of the watershed, the concentration of chloride in the surface water is strongly affected by, if not identical to, the concentration in adjacent or contiguous shallow aquifers.

At present, groundwater discharges from the shallow aquifers to the surface water in absence of pumping occurs in several locations. Areas of significant groundwater discharge include the Simi Valley area, Reach 7; the upper reaches of Conejo Creek, Reaches 12 and 13; the Santa Rosa Valley, portions of Reaches 9 and 11; and in the immediate vicinity of the Camrosa WWRF, a small portion of Reach 3. The shallow aquifers are also reported to be sources of significant volumes of water for agricultural irrigation. Shallow aquifers in the Conejo Creek vicinity were reported to produce between 2,500 to 4,400 acre feet/year between 1989 and 1995 (Santa Rosa Basin Plan, 1997). Shallow aquifers were also pumped in Arroyo Las Posas, Reach 6, by one large grower and by the Zone Mutual Water Company. Zone Mutual pumping produced 2,112 ac-ft in 1998, a wet year, and 3,333 ac-ft in 1999, a dry year.

Chloride concentration in groundwater is high enough to impair beneficial uses in some locations, especially in the upstream reaches in the vicinity of the cities of Simi Valley and Thousand Oaks. Because no data are available for groundwater quality under pristine conditions, it is not known to what extent chloride concentrations in those areas have increased, but more recent data show a general increasing trend. The Regional Board database for groundwater quality shows that concentrations of chloride have generally increased over the period of record. The 1991 Thousand Oaks report stated that during the decade from 1974 to 1983, the concentration of chloride in groundwater was stable or increasing, and attributed the increase to low rainfall. The increasing groundwater concentration affects, and is in turn affected by, surface water concentration in the watershed, by mechanisms such as the agricultural concentrating effect (described in Section 5B2 below); pumping of groundwater for dewatering, waste site remediation, and irrigation; and natural recharge and discharge, especially from shallow aquifers in particular parts of the watershed.

4C. SEASONALITY, HISTORICAL CHANGES, AND CRITICAL CONDITIONS

The predominant feature of surface water flow in the watershed is runoff from short-lived storm events, produced by the seasonal precipitation pattern typical of coastal southern California. About 15 to 20 discrete storm events occur per year concentrated in the wet-weather months, producing runoff of a duration from one-half day to several days (USGS, 2000). Discharge during runoff from storm events is commonly 10 to 100 times greater than at other times. Storm events and the resulting high stream flows are highly seasonal, grouped heavily in the months of November through February, with an occasional major storm in September, October, or March. Rainfall is rare in other months, and major storm flows historically have not been observed outside the wet-weather season.

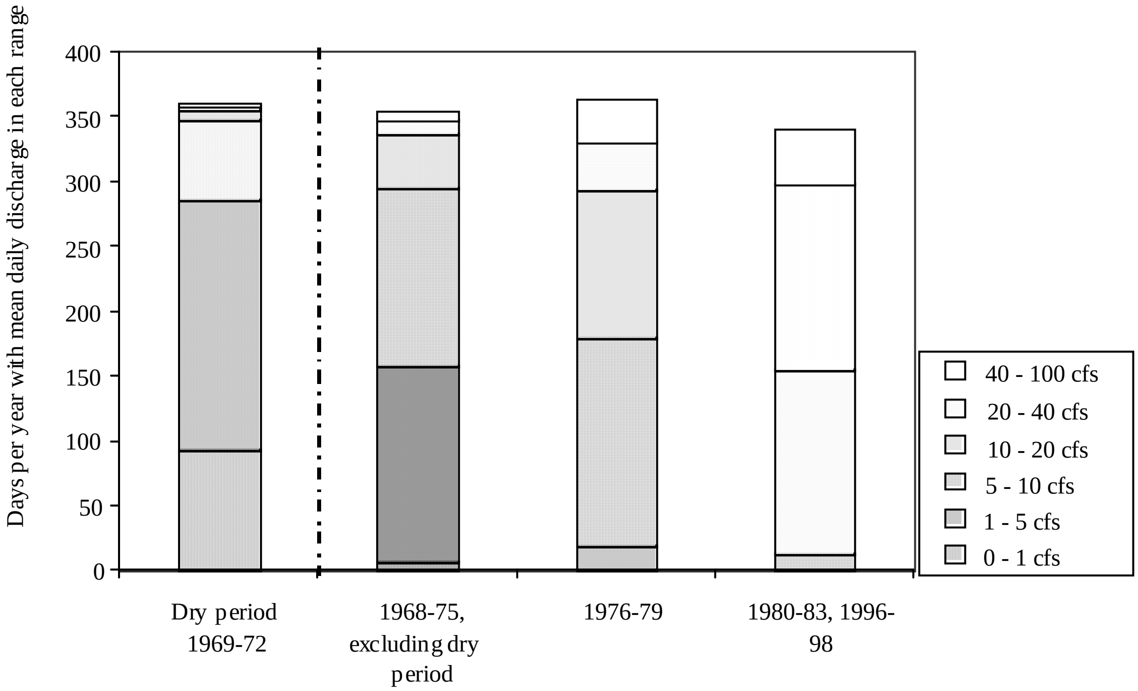
Seasonality and historical changes were evaluated using the best available historical data about flows on the waterbody. A substantial body of flow data were available from gauging stations operated by the USGS until 1983 and Venture County Flood Control District thereafter. The three locations are: Arroyo Simi at Madera Road, above the Simi Valley POTW (Reach 7); Conejo Creek upstream of Highway 101 (Reach 9); and Calleguas Creek main stem at Potrero Road (Reach 3), also known as the Camarillo Hospital gauging station. The flow data are recorded in the form of mean daily discharge, or mdd. The mdd is the 24-hour average flow for each day of the monitoring record, in units of ft^3/sec. The mdd term does not capture variability on a scale of less than one day, but as an average daily quantity, is a reasonable indicator of the variation of in-stream conditions.

4C1. Historical Changes

Historically, the magnitude of both rainfall and runoff from single storm events has varied greatly from storm to storm. Within that variation, however, the total rainfall per storm does not appear to have changed substantially over the period of record from 1973 to present, even during drought periods. As a rule, during drought years rainfall continues to occur in discrete storm events, and the rainfall per storm event is comparable to that during non-drought years; but the number of storms per year declines. Therefore, any possible critical conditions that occur during drought periods are not present during storm events, and this TMDL does not consider any changes in conditions produced by changing rainfall and runoff. (Drought periods may strongly affect other factors, such as groundwater discharge and water usage patterns in the watershed, during critical conditions; those are considered in this TMDL.)

Data show that during non-storm periods, the volume of flow for much of the Calleguas Creek system has increased compared to the 1970s. Figure 3 shows the proportion of days each with specified flow volume at Potrero Road for four historical periods. Prior to 1975, more than 150 days per year experienced mean daily discharge of less than 5 ft^3/s, but after 1975 such days were rare. After 1980, days of less than 10 ft^3/s were also rare, and most low flow days (approximately 250 days per year) were in the range of 10 to 40 ft^3/s. Flow exceeded 40 ft^3/s on about 45 non-storm days per year. Storm flow days (greater than 500 ft^3/s) continued to occur between 10 and 20 days per year. The number of non-storm days greater than 100 ft^3/s (less than 500 ft^3/s) increased slightly compared to earlier periods, but the number of storm flow days (commonly between 1,000 and 10,000 ft^3/s) remained approximately constant.

Figure 3. Proportion of days with low flow, four historical periods, Calleguas Creek at Potrero Road, USGS Camarillo gauge.



Source: USGS, 2000.

The observed increase in flow during non-storm periods through about 1980 is probably attributable to changes to the watershed that continue to exist currently, such as growing discharges from POTWs and discharges of shallow groundwater. Therefore calculations for this TMDL use USGS data beginning with the 1980 season through the most recent period available, instead of the entire period of record. For the gauging stations on Conejo Creek and Arroyo Simi, those data are from the period October 1979 to September 1983, when USGS discontinued its flow monitoring at those stations. For the main stem at the Potrero Road gauging station, data used are from that period, plus a two-year period when USGS resumed monitoring, from October 1996 to September 1998.

4C2. Seasonality

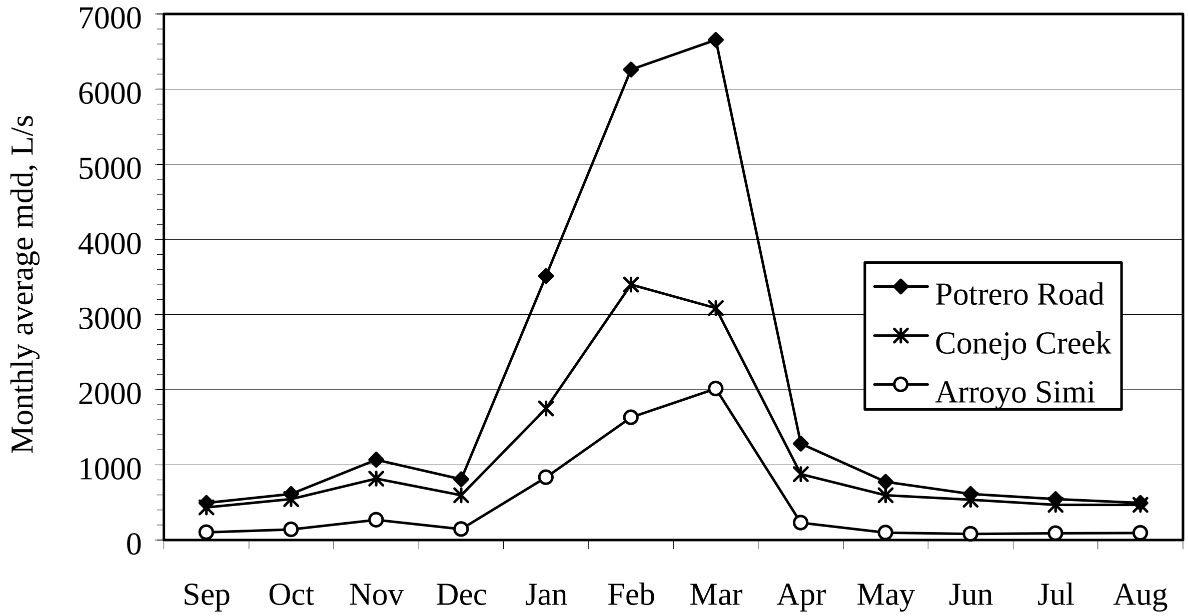
Seasonal variability is an important factor, because coastal southern California experiences a sharply divided wet-weather season and dry-weather season. Annually, the typical conditions include a small number of days with extremely high flow, concentrated into short-lived high-discharge events, typically on the order of one to two days duration, and almost exclusively occurring within a wet weather season of late September through mid-March. Figure 4 graphs the average monthly flow over the period October 1979 through September 1983. The average flow is much greater in December, January, and February than in June, July, and August. The variation about the mean is also much greater during the wet-weather months, as shown in

Figure 4. Figure 4 also shows the log-mean monthly flow, plus the standard deviation. The magnitude of the standard deviation is several times greater than the magnitude of the mean.

The extremely large standard deviation in the wet-weather months occurs because daily flow variability during those months is even more pronounced than seasonal variability. During the wet weather season, flow can change dramatically from day to day, and often is as low as dry-season flow. Discharge during storm events is commonly 10 to 100 times greater than during other days. High-flow extremes vary from year to year: on seven occasions since 1968, mean daily discharge exceeded 5,000 ft^3/sec, and on 17 other occasions was between 2,000 and 5,000 ft^3/sec. The frequency and magnitude of high-flow events does not appear to have changed appreciably since 1968. High-flow events are sharply seasonal: flow greater than about 100 ft^3/sec mdd is rare during dry-weather months.

However, the converse is not true: periods of low flow are not restricted to the dry season months, but also occur between storms during the wet weather period. For a substantial number of days each year during the wet weather season, most of the flow in the stream originates with municipal wastewater effluent, just as it does during the dry weather season. Wet-weather low flow is sufficiently frequent that low flow must be considered as critical conditions even during wet weather periods. For example, mean daily discharge on the main stem of Calleguas Creek near Camarillo is 20 ft^3/sec or less about 80% of the days during August, and about 20% of the days during February. Even during the wet weather season high flows are not observed substantially more often than low flows: for all January days since 1979, mean daily discharge exceeded 100 ft^3/sec only on about 17% of measured days. For that reason, the critical conditions evaluated here are based on not mean monthly flow, but mean daily discharge as distributed among different months of the year.

Figure 4. Monthly average discharge at three gauging stations, recent historical data: mean and log-mean, with standard deviation.



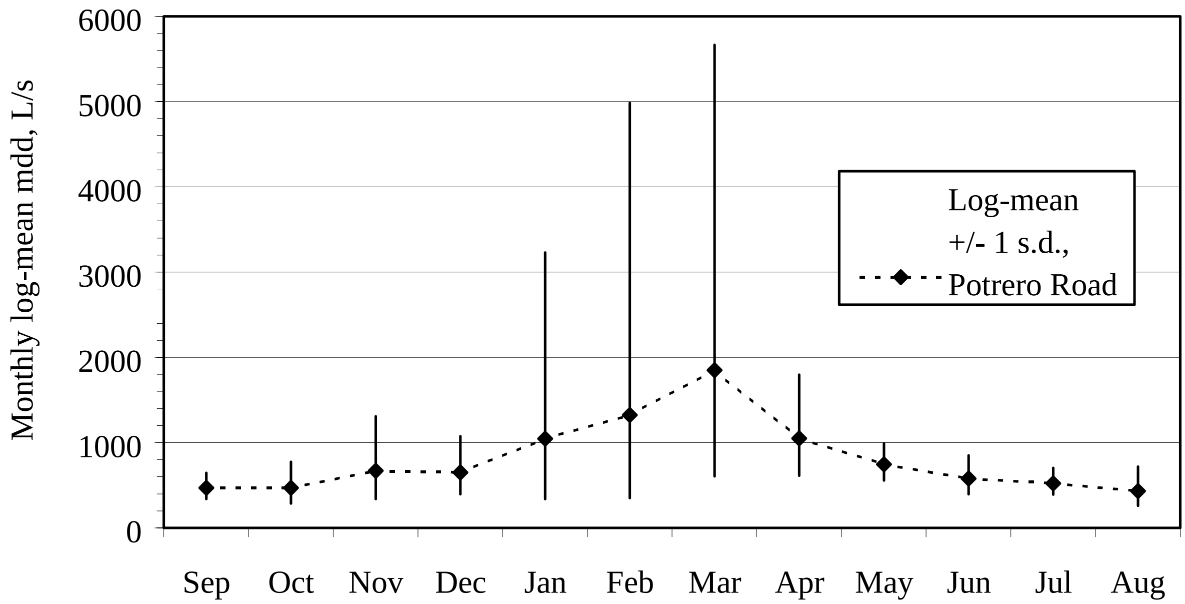


Figure 5 demonstrates wet-weather variability by graphing the mean daily discharge (mdd) for each day in a selected two-month period, January and February of 1983. High flows approach 100 times the volume of low flows. This daily variability is so great that average monthly flow is not meaningful to describe day-to-day conditions in the waterbody. The same variability holds over the long term, and is best addressed by frequency analysis, rather than analysis of seasonal averages.

Figure 6 describes the monthly patterns of flow by graphing frequency of low-flow days for the Potrero Road station, using USGS data from the 1979-1983 period. At the Potrero Road location, days with 30 ft^3/s mdd or less occurred during about 75% to 85% of the days, including more than 90% of the days during the dry weather season. However, they are not limited to the dry weather season. Flow of 30 ft^3/s mdd or less also constitute more than 50% of the days during the wet-weather months of November, December, and January, and about 30% to 40% of all days in February, March, and April. Low flow conditions are not limited to the dry weather period but are common throughout the year on Calleguas Creek.

It is not clear that lowest flow always defines critical conditions, but it is clear that storm flow provides sufficient dilution that chloride concentration does not cause impairment. The fact that a large number of days during the wet season are not dominated by storm flow suggests that seasonal flow average is not useful to define critical conditions, and that some critical conditions may occur during the wet weather season. Wet weather months cannot be excluded from controls required to reduce impairment under this TMDL. Therefore critical conditions may occur during any season of the year, and are defined not according to season but instead according to flow volume.

Figure 5. Mean daily discharge at Potrero Road gauge for selected months, January-February 1983; including monthly average discharge for period of record using recent historical data.

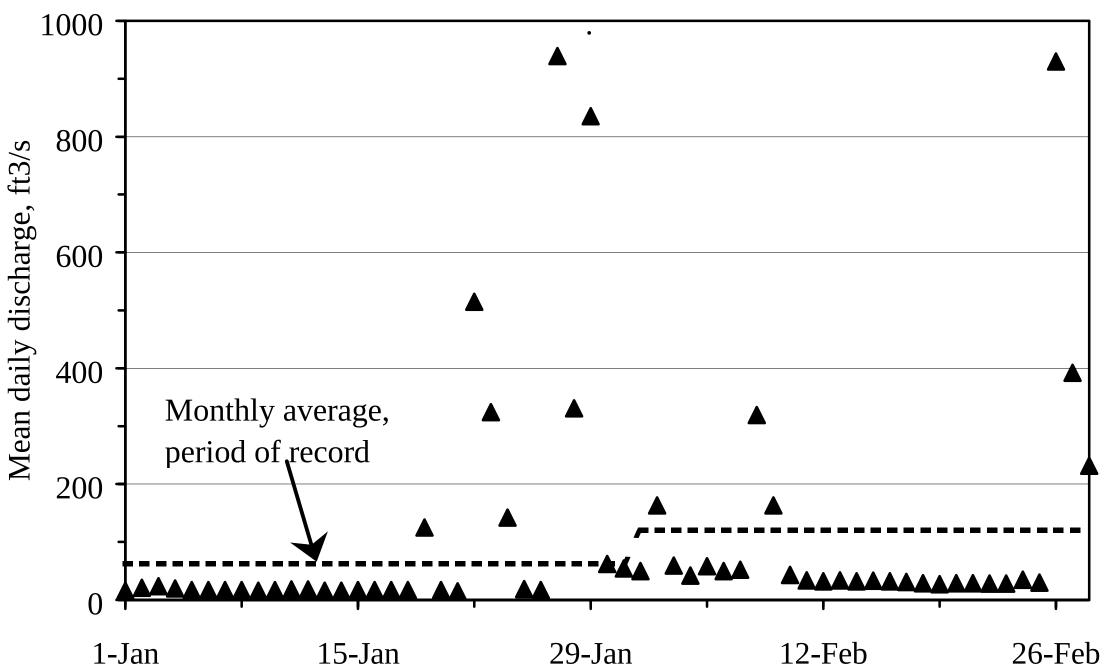
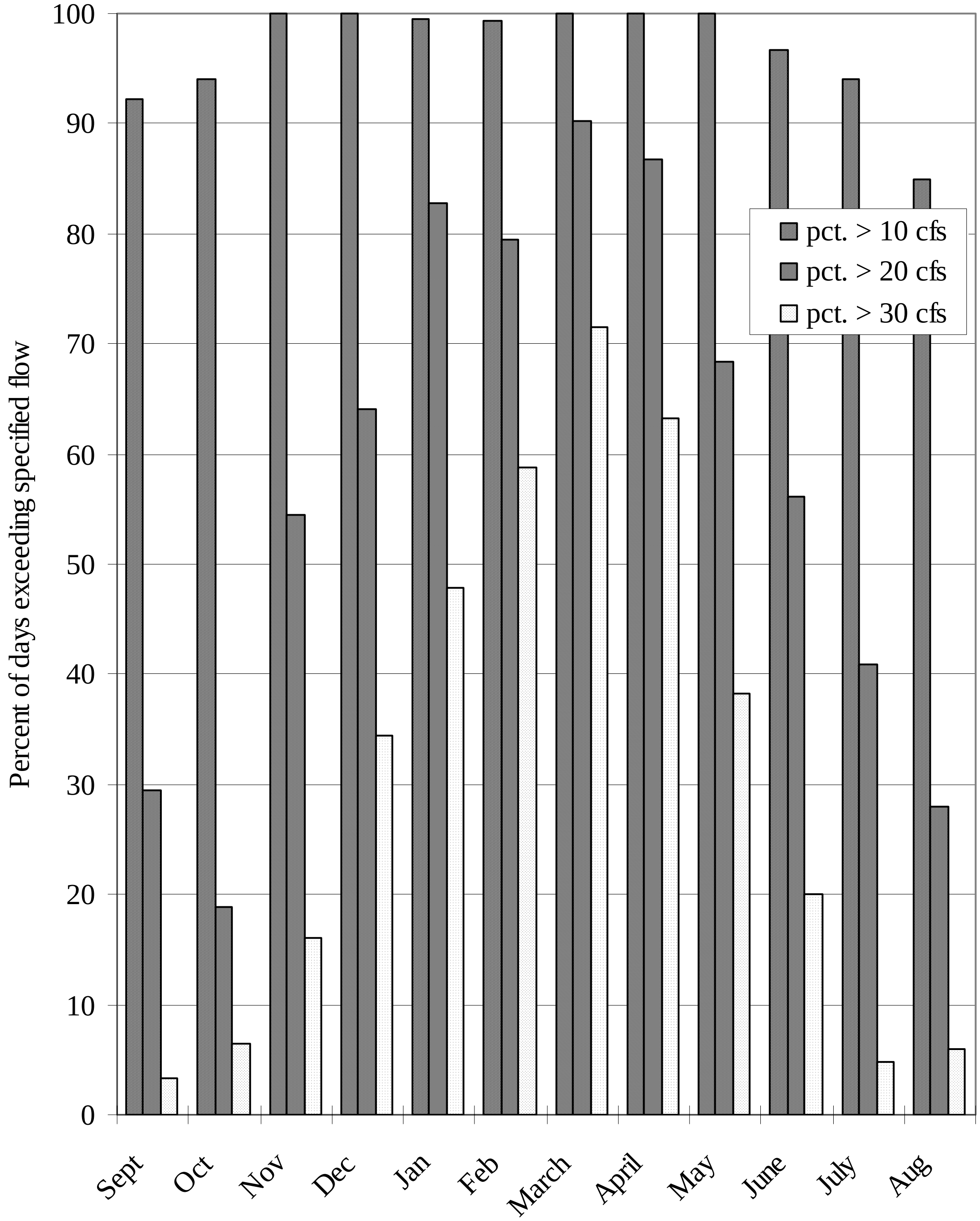


Figure 6. Proportion of days each month with low flow, Calleguas Creek at Potrero Road, USGS Camarillo gauge, 1979-83, 1996-98.



4C3. Critical Conditions

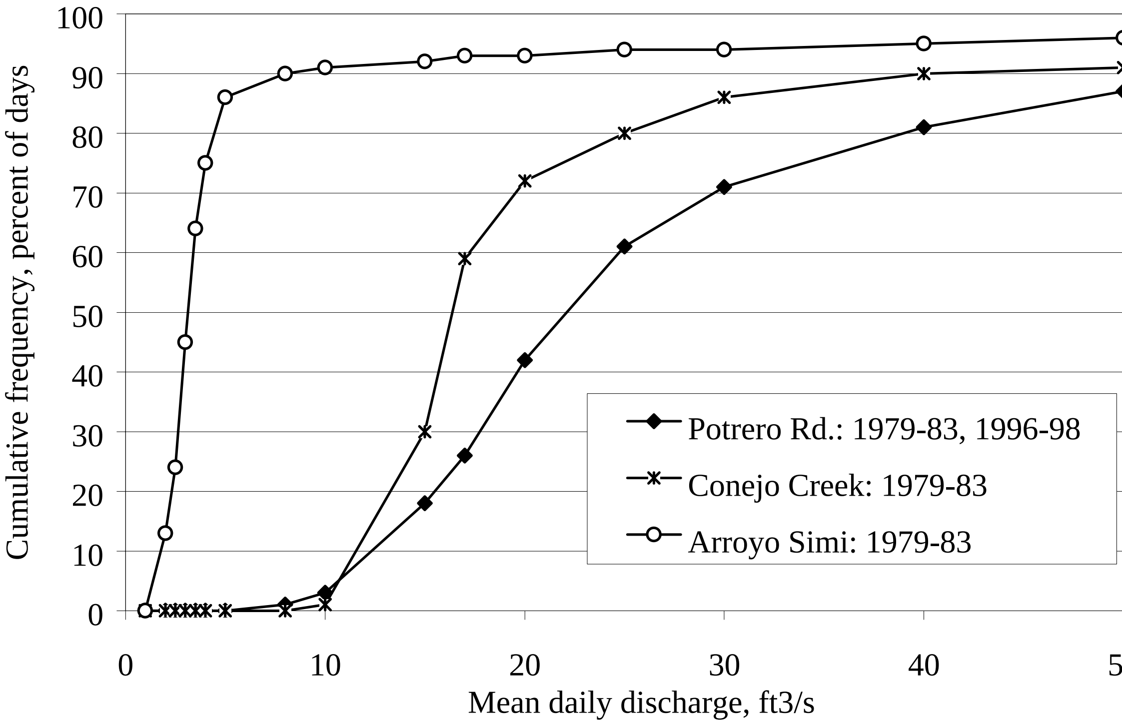
The maximum impairment for many constituents in many waterbodies occurs at the lowest flow, when the waterbody's assimilative capacity is at its lowest. Increased assimilative capacity means the waterbody can accommodate larger loads of pollutants. In the case of a chemically conservative pollutant like chloride, assimilative capacity increases when loads from point sources like POTWs (relatively constant) are diluted by other sources of flow (e.g. rainwater or groundwater discharge, when those sources do not contain the contaminant of concern). Low flows are produced by variation in the non-point sources, so critical conditions occur at lowest flow. Low flows are commonly defined using the statistically-defined term 7Q10, which means the lowest average daily discharge during any seven consecutive days within a 10-year period (USEPA 1992). The critical flow, whether defined as 7Q10 or by any other method, may be different for each waterbody, so needs to be defined using data for that waterbody.

For chloride in Calleguas Creek and tributaries, it is not clear that low flow defines the condition of maximum impairment. That is because substantial chloride sources originate with non-point sources throughout the watershed, both natural groundwater discharges and anthropogenic sources such as pumping for groundwater remediation and construction dewatering. Therefore the linkage analysis, in Section 7 below, uses a mass balance model to assess in-stream concentration for a number of different flow conditions in order to determine the greatest chloride concentration, which will define critical conditions for this TMDL.

Flow in the Calleguas Creek system varies from day to day by a much wider margin than the annual or monthly average would suggest. Storm flows are concentrated into events of one-half to three days duration, and exceed non-storm flows by one to two orders of magnitude. During non-storm periods, the flow also shows considerable variation. Discharges and recharges of shallow groundwater form a dynamic system that contributes varying amounts to surface flows in different parts of the watershed, and at different times. Factors that affect discharge and recharge include rainfall in preceding days, total rainfall over preceding months and years, agricultural irrigation practices in the vicinity of the aquifer, soil properties that change over time and differ between locations, and others. Withdrawals for agricultural irrigation and discharges of groundwater pumped from the soil in urban areas also affect streamflow. For anthropogenic sources, such as groundwater pumped for remediation and urban non-storm runoff, the flow volumes are controlled by human decisions based on a wide range of factors.

This TMDL uses cumulative frequency analysis of historical data to describe flow variability, rather than a mechanistic model that attempts to link the complex set of physical conditions affecting flow volume. That is a more useful description than averages by day, month, or season. Figure 7 plots the cumulative distribution of mdd for the three Calleguas Creek location for which USGS data are available, using data from the 1979-1983 period determined to be representative of current conditions.

Figure 7. Cumulative frequency distribution of mean daily discharge at three gauging stations, recent historical data.



Source: USGS, 2000.

The cumulative frequency can be used to quantify flow volume under various conditions. Most importantly, it allows assessment of flow during days not affected by storm discharge. Any average calculation during wet-weather months would be affected by the few days of very high storm flow, shown at the right-hand side of the cumulative distribution. However, as demonstrated in the previous section, many days during those months are not affected by storm runoff, so the monthly average is not meaningful. In Figure 7, the period affected by storms can be seen as the portion of the curves above, or to the right of, the transition from a steep increase to a flatter curve: that is, where the curve begins to show the effects of fewer high-flow events. (The transition point is more clearly defined mathematically as the transition from a normal distribution, characteristic of non-storm flow, to a log-normal distribution, characteristic of storm flow. A graphical, more-detailed analysis of that transition is provided in Appendix A.) The non-storm period is defined as the 80th percentile point for the Conejo Creek and Potrero Road gauges, and the 85th percentile point for the Arroyo Simi gauge. The non-storm period includes three conditions of interest: lowest flow; typical low flow, used to describe "average" conditions for this waterbody; and the maximum non-storm flow, which occurs at the point of transition.

The cumulative frequency analyses have been used to define flow conditions that could prove to be critical for this TMDL. Seven flow conditions have been identified, as follows:

1. **Storm flow.** Storm discharge varies considerably from one storm to the next, and conditions probably are quite different from one storm to another. However, it is not

expected that conditions are impaired during storm flow, because assimilative capacity is greatly increased. Even though storm runoff does mobilize chloride loads, in the form of washoff from urban land uses and flushing of surface layers of agricultural fields, the increased assimilative capacity greatly overcompensates for those loads. Also, the flow velocity is greatly increased in storm conditions, so any additional chloride load rapidly washes out to sea and is not expected to remain in the stream channel sufficiently long to affect surface water or groundwater. Because the stream is not expected to be impaired in these conditions, the loads and concentrations are not calculated in detail, but only in an approximate fashion that is sufficient to verify the unimpaired conditions. Storm flow is quantified as the average mdd of all days with mdd exceeding the transition point in the cumulative frequency curve. The flows are: Arroyo Simi, 32 ft^3/sec; Conejo Creek, 60 ft^3/sec; and Calleguas Creek Potrero Road, 140 ft^3/sec. This estimate would not be sufficiently precise for predicting flood stages or total annual discharge from the waterbody, but is adequate for purposes of calculating typical storm-condition concentration.

2. **Low flow (7Q10 flow).** Periods of zero flow were recorded at all three gauging stations in the late 1960s through early 1970s, prior to urban development and POTW construction. Those periods were frequent, not limited to the dry weather season, and commonly endured more than seven days. Therefore it is reasonable to model low-flow conditions assuming zero flow and zero chloride load from natural sources, described in the Regional Board staff model as groundwater discharge. (Some locations in the waterbody may have had small flows from perennial springs, but that water re-entered the aquifer in recharge portions of the stream and did not contribute to total volume at the gauging stations.) Anthropogenic discharges of pumped groundwater and urban domestic runoff vary as a result of human decisions, and most of these also include zero flow for periods well beyond days. Periods of zero flow from anthropogenic sources are sufficiently frequent that it is reasonable to assume that a ten-year period would include some seven-day periods where zero flow from anthropogenic sources coincides with of zero flow from natural sources. The mass balance model therefore estimates in-stream volume for 7Q10 low flow conditions assuming zero discharge of any sources other than POTWs, and therefore zero chloride load other than from POTW discharges. For the three gauging stations, the mass balance model calculates those flows to be: Arroyo Simi, 0 ft^3/sec; Conejo Creek, 10 ft^3/sec; and Potrero Road, 12 ft^3/sec.

3. **Typical low flow.** This is the condition that best defines the most usual day-to-day conditions on Calleguas Creek. The flow is defined statistically as the 50th percentile, or median, mdd from the cumulative frequency curves presented above. The median is a reasonable measure of centrality for a distribution sharply skewed by a small number of high-flow events originating with storm runoff. For the three gauging stations, those flows are: Arroyo Simi, 3.5 ft^3/sec; Conejo Creek, 16 ft^3/sec; and Potrero Road, 22 ft^3/sec. These flows were used to construct the mass balance model and estimate flow volume and chloride load from specific sources in the watershed, using best available data about sources and in-stream conditions. The model needs to be calibrated under those conditions because most of the available chloride concentration and load data describe "average"

conditions, and the average flow condition (excluding the contribution of storm runoff) is best estimated by the 50th percentile point.

4. **Maximum non-storm flow.** The maximum surface flow during times not affected by storm discharges is the condition when non-point discharges are at their maximum. Because those discharges contribute substantial load, that condition is of interest for this TMDL. This TMDL used a statistical method to compute the "maximum non-storm flow," or the greatest flow volume not influenced by storm runoff for the three gauging stations. The highest non-storm flow for each location was identified as the point of transition from non-storm to storm flow on the cumulative frequency graph of Figure 7. The selected maximum non-storm flow was the 80th percentile flow for both Conejo Creek and Potrero Road, and the 85th percentile flow for Arroyo Simi. The flows for the three USGS gauging locations are: Arroyo Simi, 5 ft^3/sec; Conejo Creek, 20 ft^3/sec; and Potrero Road, 32 ft^3/sec.

5. **Drought conditions.** Droughts are produced by long-term rainfall and runoff patterns, and vary in duration, runoff volume, and conditions of flow and chloride load. Each drought period is likely to produce unique conditions, and data are not available in sufficient detail, for sufficient periods of time, to create a historical statistical model that would predict future conditions. Therefore, in-stream conditions are estimated using the estimated "typical low flow" conditions in the mass balance model, supplemented by the assumption that most groundwater discharges will decline to zero. Natural discharges disappear because the water table has dropped; pumping for dewatering also declines or disappears, because construction does not penetrate to the depth of the lowered water table. Pumping for remediation is assumed to be unchanged. In addition, during drought the water purveyors in the watershed are known to supplement their water supplies by increasing the volume of water imported from outside the watershed. (Imported water is an important source at all times under current conditions.) The primary source for imported water, the State Water Project, delivers water that originates in the San Francisco Bay-San Joaquin River Delta system.During widespread drought in the Sierra Nevada that source increases in chloride concentration relative to local sources. During the most recent drought conditions, calendar year 1992, chloride load from POTW discharges increased approximately 20%. Therefore the mass balance model for drought conditions was completed assuming POTW discharges were unchanged in volume but increased in chloride concentration by 20%, and therefore an identical increase in load. The flow during drought critical conditions is: Arroyo Simi, 2 ft^3/sec; Conejo Creek, 9 ft^3/sec; and Potrero Road, 15 ft^3/sec. During the course of implementing this TMDL, when drought periods occur, stakeholders should monitor flow conditions to verify the validity of these assumptions.

6. **Immediate post-drought maximum non-storm conditions.** A potentially critical condition occurs immediately after the end of a drought period. When groundwater discharges resume, they are likely to be higher in concentration than during wet periods, because the agricultural concentrating effect has continued during the drought and has delivered chloride load to the groundwater, further concentrated by the absence of discharges which if present would help to flush the chloride from the aquifer.

Groundwater discharges have been shown by historical data to increase in chloride concentration following a drought period, but data are inadequate for a statistical estimate. Therefore the chloride concentration is in groundwater discharges is estimated at 20% greater than the concentration during "typical low flow" conditions as described in item 3 above. The most critical conditions will occur at maximum non-storm flow, when these discharges reach their maximum, which is expected to be possible during some days beginning immediately after a drought ends. Further, in the immediate post-drought period, the imported water supplied by domestic water suppliers in the watershed may still be higher in chloride than during non-drought periods, so the POTWs may continue for a time to discharge effluent with 20% greater chloride load than during non-drought periods. That combination of worst-case conditions is used to compute the critical conditions during immediate post-drought periods. The flow is computed using the maximum non-storm flow assumptions, and so is identical: Arroyo Simi, 5 ft^3/sec; Conejo Creek, 20 ft^3/sec; and Potrero Road, 32 ft^3/sec.

7. **Flow variation from expected Camrosa Diversion.** A proposal currently approved by the State Water Resources Control Board will allow for diversion of in-stream flow in Reach 9, at the point where it has been divided into Reaches 9A and 9B. Flow remaining in the stream will be approximately 6 ft^3/sec at all times (except during storm flows), the minimum acceptable to support habitat beneficial uses. The mass balance model has been conducted to compute chloride concentrations that will result from that diversion. The only USGS gauge where flow is affected will be the Potrero Road gauging station. At that location, after the diversion is implemented, the flows during various conditions are projected to be as follows: during 7Q10 lowest flow, 11 ft^3/sec; during typical low flow, the same 11 ft^3/sec, because essentially all the excess non-storm flow will have been diverted; and during maximum non-storm flow, 14 ft^3/sec, augmented only by the increased groundwater discharge in Reach 3 and Reach 9B.

The above conditions are defined quantitatively by a variety of methods. Conditions 1, 3, and 4 in the list are defined entirely based on historical stream flow data for the three gauging stations. Results of the analysis for Condition 3, typical low-flow conditions, are used to calibrate the mass balance model to support best estimates of flow volume for the known inflows and outflows for other flow conditions. Then, Conditions 2, 5, 6, and 7 are defined by making changes to inflows and outflows in the mass balance flow model using known information about changes to sources and flows under specified conditions. Some of these changes, such as volume of the Camrosa Diversion in Condition 7, are well-defined. Others, such as changes during drought for Conditions 5 and 7, require additional estimates or assumptions about particular inflows and outflows to the waterbody.

The flows were defined for the three locations in the watershed where USGS data were available: Arroyo Simi at Madera Road; Conejo Creek above Highway 101; and Calleguas Creek at Potrero Road. For each set of conditions, flow is quantified for the other reaches using the mass balance model, described in Section 7, along with the best available information about inflows and outflows to all reaches of the Calleguas Creek system.

5. SOURCE ASSESSMENT

Figure 2, the map of flow sources, also shows the location of loads to the waterbody. The figure includes POTWs, groundwater discharge, and urban non-storm runoff. Table 5 summarizes the sources of chloride to the waterbody, listed under the reaches that receive each discharge. The major sources, ordered from largest to smallest, are: discharges of treated municipal wastewater; groundwater discharge; and urban runoff. Table 5 displays all loads in terms of lb/day converted to an equivalent annual average, including the loads from urban stormwater runoff which occur on only 15 to 30 days of a typical year.

5A. TREATED MUNICIPAL WASTEWATER

Table 5 includes the estimated loads and the associated flow volumes for discharges from the five POTWs in the watershed. Three of these discharge treated wastewater into the surface waters: Simi Valley Water Quality Control Plant; Hill Canyon Wastewater Treatment Facility; and Camarillo Wastewater Treatment Plant. In non-storm conditions, the three surface discharges constitute the greater part of the surface flow in their reaches. The loads and discharge flows for those three facilities use data for calendar year 1999 from daily volume and constituent concentration measurements under NPDES permit requirements. The total chloride load to the watershed from POTW discharges is about 21,200 lb/day, as summarized in Table 5. That total does not include loads in discharges from the Moorpark and Camrosa POTWs. Those loads are readily quantified, but are assumed to enter the watershed indirectly via groundwater (discharges through natural processes in the vicinity of the POTWs and/or pumping of shallow groundwater for irrigation), and because they are necessarily incorporated in loads attributed to groundwater they are not included in the total here to avoid double-counting of those loads. Calculations assume POTW discharge data for 1999 are representative of conditions for the foreseeable future.

As mentioned above, there are two POTWs that discharge into the shallow aquifer system. The Camrosa WWTP discharges into the shallow aquifer system of Reach 3. The aquifers are heavily used for various beneficial uses, and are in close communication with the surface flows of the waterbody. The Ventura County WWTP (Moorpark) discharges treated municipal wastewater into the shallow aquifer system of Reach 6, Arroyo Las Posas. In 1999, the average concentration was about 114 mg/L. The discharge is lower in chloride concentration than the current, impaired condition of the shallow aquifer in this vicinity, although it is greater than the WQO proposed for this reach so that chloride load from the discharge needs to be reduced if the impairment is to be removed. The aquifer appears to be substantially more impaired upstream of the discharge than downstream, so that upstream sources may be seen to have important impacts on the shallow groundwater.

Table 5. Summary of Chloride Loads and Source Activities by Reach (Long Term Annual Average)[#]

Reach	Treated Municipal Wastewater (POTWs)			Groundwater			Miscellaneous Other		
Discharge	**Flow ft^3/s**	**Conc mg/L**	**Mass lb/day**	**Flow ft^3/s**	**Conc mg/L**	**Mass lb/day**	**Flow ft^3/s**	**Conc mg/L**	**Mass lb/day**
Tapo Canyon, Reach 8									
Groundwater discharge				0.5	160	427			
Urban non-storm runoff							0.5	130	347
Arroyo Simi, Reach 7									
Groundwater discharge above USGS gauge station				0.5	160	427			
Urban non-storm runoff							0.5	100	267
Groundwater discharge below USGS gauge station				1	150	801			
Pumped groundwater**							1.5	150	1,202
Simi Valley POTW	14.1	113	8,508						
Arroyo Las Posas, Reach 6									
Moorpark POTW*	3.1	118	1,953*						
Conejo Ck S Fork, Reach 13									
Groundwater discharge				0.5	160	427			
Pumped groundwater**							0.5	160	427
Urban non-storm runoff							1.5	160	1,282
Conejo Ck N. Fork, Reach 12									
Groundwater discharge				1	150	801			
Urban non-storm runoff							1.5	150	1,202
Arroyo Santa Rosa, Reach 11									
Groundwater discharge				0.8	130	555			
Urban non-storm runoff							1	100	534
Conejo Ck Hill Cyn, Reach 10									
Hill Canyon POTW	15.2	118	9,572						
Conejo Creek Main Stem, Reach 9B									
Groundwater discharge				1	150	801			
Urban non-storm runoff							0.5	100	267
Sub-Surface Inflow							0.5	126	337
Conejo Creek Main Stem, Reach 9A									
Groundwater discharge				0.5	150	401			
Camarillo POTW	3.3	175	3,084						
Calleguas Creek, Reach 3									
Groundwater discharge				1	250	1,335			

Agricultural discharge**							1	250	1,335
Camrosa POTW *	2.3	250	3,071*						
Rising groundwater near Camrosa POTW				1	250	1,335			
TOTALS			21,200			7,310			7,200

[#] At typical low flow, defined as 50th percentile based on historical flow (Section 6.1, Flow Condition; Figure 4).

* Discharge to groundwater, therefore load and flow are not included in in-stream totals.

[**] See discussion under Section 4.3, Minor Sources.

Discharges from the five POTWs vary seasonally, but the variation does not appear to be of similar direction or magnitude at all five facilities. For the most part, the total load and total flow are greatest during the wet weather months; slightly less during the spring/summer period; and at their lowest during the autumn period. The most strongly influenced by that pattern is the Ventura County WWTP, which discharges a fairly constant volume year-round but markedly lower chloride load in autumn and spring/summer (about 1,600 lb/day) than during the wet weather season (about 1,900 lb/day). Conversely, Hill Canyon WWTF shows a higher load but lower flow during the autumn period than during the spring/summer period. It is not clear what factors govern the observed variation in discharge volume and chloride concentration.

5B. GROUNDWATER DISCHARGE

Groundwater enters the waterbody in a number of locations in the form of natural discharges from shallow aquifers. These discharges are a major source of chloride to the surface water, totaling approximately 7,310 lb/day across the entire watershed on an average annual basis, as shown in. The chloride enters the groundwater from various sources by multiple mechanisms. Loads are estimated using discharge volumes and relevant chloride concentrations reported by various water agency studies, concentration data from in-stream measurements of the CCCS collected during 1999, and inferences about the proportion of in-stream flow originating as groundwater. In addition, in several locations in the watershed groundwater is pumped for remediation or for construction dewatering of shallow aquifers, and then discharged under WDR permits. These are considered minor sources, and are addressed separately in the linkage model below.

Groundwater enters the surface water by natural discharge in four general regions of the watershed. These are tabulated in Table 5, and summarized below.

Upper Arroyo Simi, Reaches 7 and 8, from the headwaters to just below the Simi Valley POTW. Groundwater discharge accounts for essentially all the flow measured at the USGS gauging station at Highway 23, so in-stream monitoring from the CCCS and other sources are a reasonable estimate of groundwater concentration. Discharge in Reach 8 includes some dry-weather runoff, a minor source discussed below, so the model has been adjusted to incorporate that estimated load. The estimated load from groundwater discharge by natural processes is about 1,700 lb/day, as listed in Table 5.

The Conejo Creek headwaters, including the Conejo Creek North Fork (Reach 12) and South Fork (Reach 13). The reaches contain a number of natural and anthropogenic groundwater discharges. The load from groundwater discharge for the two reaches as a whole, as presented in Table 5, is estimated at 1,300 lb/day using the average concentration of the 12 in-stream CCCS measurements at a point below the North and South Forks confluence, and the flow was estimated by a regional study in 1987 (Boyle Engineering (1987)). The anthropogenic portion of the load is included within the Table 5 total, and further described below.

The Santa Rosa Valley, encompassing the lower part of Arroyo Santa Rosa (Reach 11); a small part of the downstream end of the Hill Canyon area (Reach 10); and Reach 9B in the Conejo Creek main stem. Much of what is known of groundwater recharge and discharge in this area, as in the Conejo Creek headwaters upstream and the Calleguas Creek main stem downstream, comes from a study as part of the Santa Rosa Basin Groundwater Management Plan (Boyle Engineering, 1987). The chloride load from groundwater discharge in the Santa Rosa Valley is about 555 lb/day. The region overall is dominated by areas of groundwater recharge, so that groundwater discharge and accompanying chloride loads are relatively small.

In the Calleguas Creek main stem, studies have shown rising groundwater contributing at least 2.0 ft^3/s in the vicinity of the Camrosa POTW. Sources of chloride in this discharge are expected to be a) agricultural drainage from the nearby intensively irrigated agricultural areas, b) municipal wastewater entering the shallow aquifer system from the Camrosa POTW spreading facilities, and possibly c) dissolution of chlorides from shallow sediments and volcanics with which the groundwater is in contact. Because of the documented high concentration of 250 mg/L in this groundwater, chloride load from groundwater discharge in this reach is considerable, estimated as a total of about 2,700 lb/day, as shown in Table 5.

The chloride loads from human-produced groundwater discharges are calculated using Waste Discharge Requirement (WDR) permit information. Those are described under “minor sources” in Section 5D below. Loads from natural groundwater discharges are less precise. The loads are calculated using concentration data from groundwater monitoring where available, and using best estimates of discharge flow inferred from in-stream flow measurements and knowledge of discharges other than groundwater contributing to that flow. In some reaches, the groundwater load was calculated using in-stream concentration data as well as in-stream flow data. In those reaches, the best concentration information in most cases is the measurements collected by the CCCS in 1998 and 1999, along with similar inferences about the proportion of flow originating as groundwater discharge. Because the reasons for variation in groundwater loads and concentrations are not well understood, further monitoring should be conducted during the implementation phase of this TMDL to determine whether additional critical conditions are present, either seasonally or over the longer term. If that it the case, this TMDL should be revised to protect beneficial uses under those conditions.

5B1. Septic Systems' Contribution to Groundwater Loads

If properly sited, maintained, and operated, septic systems do not discharge directly to the waterbody. Septic systems are not considered sources of chloride to Calleguas Creek and therefore do not appear in Table 5. However, domestic wastewater is a known source of chloride, and the chemically conservative nature of the substance means it can be accumulated and transported in the soils and aquifers of the watershed. Wastewater discharged through septic systems is considered to be one origin of chloride present in groundwater, so the loads from septic systems are reflected in the Table 5 loads tabulated for groundwater discharges. Reducing chloride discharges by residences into septic systems, by one or more potential best management practices encouraged or enforced by stakeholders, could be one way to implement this TMDL, so the characteristics of septic systems are discussed briefly here.

Septic systems are most widely used in unincorporated areas of the watershed, in particular the Santa Rosa Valley (Reach 11) and unincorporated parts of the Arroyo Las Posas and Arroyo Simi areas (Reaches 6 and 7). Assumptions about population distribution suggest about 25,000 persons are served by septic systems in the Santa Rosa Valley, an area not served by sanitary sewer utilities (Santa Rosa Mutual Water Company, 1997). In other parts of the watershed, primarily the Arroyo Las Posas/Arroyo Simi area, another 100,000 persons inhabit unincorporated areas or small municipalities. For those areas, the proportion of population served by septic systems is estimated by comparison with patterns in the neighboring Santa Clara watershed, where approximately 10 persons per 1,000 population in such areas are served by septic systems. That proportion implies a total of about 1,000 septic systems in the Arroyo Las Posas/Arroyo Simi reaches. Assuming an average chloride load of 0.11 lb/day per septic system (Septic Tank Practice, USHEW, 1972), the total chloride loads are approximately 200 lb/day to the watershed in the drainage areas of Reaches 6 and 7, and 2,700 lb/day in the drainage area of Reach 11. Those loads are not tabulated in Table 5, but are indirectly reflected in loads tabulated as originating with groundwater discharges.

5B2. Irrigation Loads and the Agricultural Concentrating Effect

Agricultural irrigation is not included in Table 5 because it is not considered a chloride source (with one exception, described under Minor Sources in Section 5D). It is not considered a chloride source because of two assumptions. First, application of water for irrigation is assumed not to add chlorides to the residual water, with the exception of negligible amounts that may be present in applied fertilizers, applied pesticides, or topsoils with which the water comes into contact. Any chloride mass concentrated by the irrigation activity is assumed to be already present in the source water and to be merely circulated within the watershed, not added as a new source. Second, it is assumed that no irrigation water enters surface waters. This is a reasonable assumption if agricultural operators may be expected to apply the minimum acceptable amount of water, a costly resource. The minimum effective amount of water for irrigation is that quantity where all water is taken up in the root zone. In that case, no residual water runs off as tailwater, and none enters the shallow ground water directly. (The exception is fields equipped with tile drains, which are considered separately as minor sources in Section 5D.)

Agricultural irrigation activities do not add chloride load to the watershed, but they do serve to concentrate chlorides already present in irrigation water withdrawn from surface water or groundwater. Chloride mass contained in applied irrigation water is left in the soil when water is taken up by crops, or when water evaporates from the fields. The water then leaves the system, either through evapo-transpiration into the atmosphere or through incorporation into the tissue of the crops. For the most part, this chloride remains in the root zone until it is mobilized by water in larger quantities than the typical irrigation practice. The built-up chloride is leached out of the root zone when the fields receive heavy precipitation or when farmers intentionally apply water in leaching amounts. That water conveys the chloride, deposited from previous irrigation water, into the groundwater or into tile drains if they have been installed. The movement of chloride from agricultural uses into either the groundwater or the surface water, through tile drains, therefore is not considered a source of chloride load.

One condition under which agricultural irrigation constitutes a new load is when water is imported to the watershed and applied for irrigation. In that case, any chloride contained in the applied water eventually becomes an additional load to the groundwater; and in locations where the groundwater is shallow and discharges to the surface water, the contained chloride becomes an additional load to the waterbody. In typical years water is imported for irrigation in small or negligible amounts, but during drought years irrigation water may be imported in substantial quantities, and that imported water is higher in chloride because of the effects of the drought on the supplying aquifers. In those cases the load might be considerable. That load is estimated in the Linkage Analysis below in the form of increased load from groundwater discharge during and immediately following drought conditions. Future monitoring might target groundwater discharges during and after drought periods to better quantify the changes in chloride concentration after prolonged periods of lower-than-normal rainfall.

5C. URBAN STORMWATER RUNOFF

The load from urban runoff is estimated using data from the nearby Ballona Creek watershed in Los Angeles County. Concentration of chlorides in Ballona Creek runoff averaged approximately 20 mg/L in 1999 (County of Los Angeles, 2000). This is a conservative estimate for runoff in the Calleguas Creek watershed, because the urban areas are somewhat less densely developed than those in the Ballona Creek watershed, and industrial or commercial land uses occupy a smaller proportion of urban areas. Aerial photography (Airphoto USA, 1997) can be used to estimate urban land use at about 20% of the watershed, or just over half the area zoned for urban land uses (County of Ventura General Plan, 1992).

The total load from urban storm runoff may be calculated using the following assumptions about storm conditions. The in-stream storm runoff discharge is calculated using USGS data since 1980 at the three gauging stations, assuming storm discharge is described by days where discharge is in the highest 5% of all daily measurements. Mean daily discharge during storm conditions is estimated as the average daily discharge of that 5% of all days. Those flows are: Arroyo Simi, 150 ft^3/sec; Conejo Creek, 200 ft^3/sec; and Calleguas Creek, 370 ft^3/sec. Urban land uses are assumed to produce 20% of total runoff measured at the three gauging stations. The chloride load from urban runoff is estimated using 25 mg/L chloride on all urban runoff, and calculating urban runoff volume as 20% of total runoff volume. Using that method, the total load from urban runoff is 35,000 lb/day of chloride, in terms of average daily load calculated on an annualized basis. The annualized basis is used for comparison to other loads, but the loads occur on a very different time period, concentrated within 15% to 20% of the days of a given year and generally dominated by discharges on only 15 to 20 days per year (4% or less of annual days).

Table 5 does not include a calculation of loads from storm runoff. That is because those loads occur during storms, when the waterbody is not impaired because of the high flow and greatly increased assimilative capacity, as described in Section 4C3 above. The urban runoff loads are dominated by the few days of a given year when the waterbody is not impaired, while the loads tabulated in Table 5 all are computed on an annualized daily basis which is dominated by discharges during periods when the waterbody is impaired. Load from urban runoff is not comparable to other loads, so it is not included in Table 5 to avoid confounding impairment-causing loads with non-impairment-causing loads.

5D. MINOR LOADING SOURCES

Three kinds of minor sources have been identified in the watershed, and contribute small chloride loads. Groundwater is pumped for dewatering or aquifer remediation under separate permits at multiple locations. Dry-weather, non-storm runoff occurs in many parts of the watershed, as is typical in urban areas where residential or commercial lawn watering is present; in one part of the Calleguas Creek watershed, Reach 8, this runoff has been identified as contributing chloride load, on at least some occasions. Agricultural tile drains, where present, convey chloride from the root zone of agricultural fields into the waterbody. These are present in only a few locations of the watershed.

Groundwater is pumped for construction dewatering in the urbanized areas of Reaches 7 and 8, where the high water table of the perched aquifers underlies regions of urban construction. That condition is found primarily in and around the municipality of Simi Valley. The total load from these sources is estimated as 1,200 lb/day, using average chloride concentration and flow volume data from WDR reports submitted in 1999 by permitted dischargers. That constitutes a substantial fraction of the groundwater chloride load in those reaches, supplementing a load of about 1,650 lb/day from natural discharge processes.

Groundwater is pumped for remediation of hazardous materials spills in various locations in the watershed, largely concentrated in the Thousand Oaks area (Reach 13, Conejo Creek South Fork). The water may be intensely treated to remove hazardous substances, after which it is sometimes permitted for discharge to the waterbody; but commonly it is not treated for removal of chlorides, which pose no health hazard and typically are present not as a result of a spill but from the various sources of groundwater chloride concentration described above. Therefore chloride loads in these discharges can be substantial, especially if the pumping occurs in an aquifer where chloride concentration is high. The current total load is estimated at about 420 lb/day, in Reach 13, based on average chloride concentration data from WDR reports submitted in 1999 by currently permitted dischargers, summarized in Table 6. Those activities change in location and discharge volume depending on identified hazardous waste mitigation requirements, so the estimate is only an approximation of expected future conditions, but the magnitude of the load is small compared to other sources. The load is included Table 5.

Table 6. Chloride loads in 1999 permitted pumped groundwater discharges, Reach 13.

Discharger	*Chloride conc., mg/l*	*Flow, ft^3/s*	*Load, lb/day*
Northrop	230	0.017	21
Rockwell (Tonexant)	216	0.033	39
Teleflex	128	0.15	100
Al-sal	150	0.056	45
Chevron	150	0.067	54
Chevron	150	0.067	54
Emery	720	0.00046	1.8
ARCO	219	0.017	20
Mobil	310	0.017	28
Mobil	150	0.067	54
	Total:	**0.50**	**420**

Load and flow figures rounded to two significant figures.

Urban non-storm runoff in the form of dry-season flow has been identified and monitored infrequently in recent decades in Tapo Canyon (Reach 8), including some instances with relatively high concentrations of chlorides. One possible source is believed to originate from a number of small agricultural nursery operations, where irrigation water may run off periodically, and may contain chlorides added to soils in fertilizers. Another possible source is a relatively large mining operation at the head of the canyon. Soils and rocky substrates are exposed in varying locations and areas over time depending on mine activities. Some substrates may be relatively rich in chlorides, and when in contact with discharge water may convey chloride to the waterbody. The in-stream discharge was sampled on six occasions between 1962 and 1981, and the load attributed to this source is estimated as the average flow and chloride concentration of the six samples, or about 347 lb/day on an annualized basis.

The final minor source is agricultural drainage through tile drains or other conveyances. This occurs in only a limited number of locations in the watershed. Tile drains are common in Revolon Slough (Reach 4) and the Beardsley Channel (Reach 5), but those reaches are not considered to be impaired for chloride and so are not addressed in this TMDL. In reaches that are impaired, only Reach 3 is known to be affected by agricultural tile drains, found in the area downstream of the city of Camarillo. Because tile drain discharges enter the surface waters of Calleguas Creek, they may in the future be subject to regulation and enforcement differently than agricultural discharges to groundwater, for example under non-point source pollution control rules currently being considered by State Board and Regional Board. An estimated 1,335 lb/day chlorides enter the waterbody through tile drains in Reach 3, as shown in Table 5.

6. NUMERIC TARGETS

The numeric targets for this TMDL are based on the concentration-based water quality objectives (WQOs) of 150 mg/L, applied as instantaneous maximum, consistent with the Regional Board's long standing practice of applying WQO in the Basin Plan (CRWQCB-LA 1994). Table 4 summarizes the WQOs used for calculating the numeric targets.

For reasons described in Section 8A below, the numeric targets for total chloride loads by reach are specified using an approximate margin of safety of 10%. Therefore, in reaches where the WQO is 150 mg/L, the numeric target is 136 mg/L. The margin of safety is intended to accommodate uncertainty in the available data used to compute the loads and linkages, and uncertainty in the physical environment.

7. LINKAGE ANALYSIS

The linkage analysis of a TMDL process is intended to characterize the physical relationship between sources of the pollutant and impaired conditions in the watershed. Some chloride sources in the Calleguas Creek watershed originate as point discharges, and others as non-point discharges, but all have geographic specificity. Conditions in impaired reaches of the waterbody are functions of a wide variety of factors including: the timing, magnitude, and location of sources; transport and transformation of the pollutant in the stream system; and the assimilative capacity of each reach, which is in turn primarily a function of hydrology and the amount of water present in the reach.

7A. MASS BALANCE MODEL STRUCTURE AND CONNECTIVITY ASSUMPTIONS

For a chemically conservative pollutant such as chloride, the linkage analysis is simplified because it needs to consider only transport, not transformation, of the substance. Therefore the linkage analysis was conducted with a mass-balance model based on spreadsheet-style calculation of inflows and outflows for each reach. Section 7A describes the model assumptions, the input information about chloride sources and reach interrelationships during critical and non-critical conditions, and the resulting use of the model to predict the impact of specified load allocations for this TMDL. The mass balance model uses a plug-flow approach, so discharge from an upstream reach to a downstream reach is computed using the equation:

$$Q\ out = Qin_1 + Qin_2 + \ldots + Qin_n - Qwithdrawals$$

The model assumes immediate and complete mixing of all inputs within each reach, and no chemical changes in the constituent of concern within the waterbody. Therefore in-stream conditions for each reach are calculated using flow volume and chloride concentration of inflows to the reach, using the equation:

$$C\ out = (Cin_1Qin_1 + Cin_2Qin_2 + \ldots + Cin_nQin_n)/Qout$$

Withdrawals and outflows from each reach are assumed to convey chloride in the same concentration, the concentration produced by mixing within the reach.

The model was based on best available information. All data were used in constructing the model; that is, all assumptions about inflows, outflows, and their associated concentrations were consistent with one another, and the model calculations produced a set of results that agreed reasonably well with measured conditions. The measured conditions for in-stream flow were reasonably precise at three locations, where USGS flow data were available as daily measurements over a number of years. The measured concentration data, and measured flow data for the many inflows and outflows incorporated in the model, were of varying precision depending on the type and extent of data and analysis available from published data, public agency reports, past Regional Board studies, and other sources available.

The model was not validated. That is, the model was not tested for a known set of conditions, by using the input assumptions and model relationships to predict a set of results for known conditions measured on a particular day, and verifying that the predicted results closely match the measured information. That validation was not possible because available data are limited, and no one day or set of conditions is available when a consistent set of measured data are available for all the multiple discharges, withdrawals, groundwater recharges and discharges, and in-stream conditions at a single time. The data that are available all represent averages of grouped data, and not a single set of consistent conditions for all model inputs that can be used to test against the model predictions. For that reason, all the available data were used in some form in developing the model itself, and data were not kept out of the model development in order to preserve a testable data set for model validation.

The model was used to conduct a linkage analysis, by predicting conditions at various locations in the waterbody under changing conditions. This analysis was used to evaluate the potential impact of dischargers' proposed changes and their ability to meet the numeric targets in this TMDL. The analysis also allowed verification that the greatest chloride concentration occurs during the identified critical conditions, which ensures that this analysis will lead to WLAs and LAs that protect water quality under all conditions. Finally, the analysis was used to evaluate whether the numeric targets will be attained, when the dischargers achieve the specified WLAs and LAs.

7B. DATA SOURCES AND ASSUMPTIONS FOR LOADS, INFLOWS AND OUTFLOWS

The model requires information for all inflows and outflows at a number of locations, and in several conditions, where few or no measurements have been made of flow volume or chloride concentration in the waterbody. Data collection in the watershed has been reasonably intensive, but even greater data would be required to fully characterize flow and chloride load conditions for all inflows and outflows and at all locations in the waterbody. In cases where adequate data were not available, Regional Board staff made assumptions about flow and chloride load consistent with the best available data. These assumptions were necessary for the model to estimate impaired conditions in some parts of the watershed, and to approximate the influence of known chloride sources on those impairments. All assumptions have been made consistent with the best available information, and using the best technical judgment of Regional Board staff.

Most of the data used to develop the mass balance model were obtained from a few key data sources. The USGS flow data for 1979 through 1983 at three locations, as described in

Section 4, were taken to be the most reliable estimator of typical daily flow volume. The Calleguas Creek Characterization Study (LWA, 2000), hereinafter called the CCCS, was the best available data for recent chloride concentration in surface water. The CCCS measured concentration at a number of locations not previously well studied, including reaches believed to be dominated by groundwater, so those data were assumed to be indicative of some groundwater chloride concentrations. The Santa Rosa study (Boyle Engineering, 1987) evaluated inflows and outflows to the shallow groundwater basin in the Santa Rosa Valley. Volume and chloride concentration were measured or estimated using mass-balance methods for known major flows, including agricultural withdrawals; urban non-storm runoff; subsurface flows; and in-stream flows. Groundwater volume and concentration were taken from a number of recent groundwater studies, including Bachman (1999), Rincon Consultants (1998), Montgomery-Watson Associates (1995), and CMWD/MWDSC (1989).

In some cases, various previous studies did not agree on flow or concentration characteristics. For example, the CCCS suggested substantially greater flow in Reaches 9 and 10, in particular inflow from Reaches 12 and 13, than are supported by the USGS data or the Santa Rosa Valley study. Similarly, the CCCS suggested substantially greater outflow from Tapo Canyon and the headwaters of Arroyo Simi than can be justified by the model given USGS measurements at Arroyo Simi. In places where data did not support a firm consensus, Regional Board staff made assumptions based on judgments about the most recent data, the most robust data, and the data that best represent the specified standard conditions.

Urban non-storm water runoff enters the channel in a number of places. In most cases this has not been studied well enough to be quantified, so flow volumes are estimated based largely on whether observed in-stream flow is greater than expected given upstream flows. The Regional Board staff are unaware of chloride concentration data in non-storm water runoff specific to the Calleguas Creek watershed. The non-storm water is assumed to have a higher concentration than 20 mg/L.

The model assumes that inflows from agricultural irrigation are negligible throughout the waterbody. This is predicated on the assumption that farmers apply only the minimum necessary irrigation water for crop productivity, such that all applied water is taken up by crops in the root zone. Irrigation is therefore not treated as a source of flow or chloride load in the model, with one type of exception. Fields drained by tile drains are treated as sources to surface water, and are so indicated in the mass balance calculations.

The model assumes in-stream chloride concentrations at several key points are well represented by the one-year, twelve-sample measurements taken by the CCCS (LWA, 2000). The average of the twelve data points was used for concentration at key points in the waterbody, and assumed to be indicative of concentration during all seasons. That assumption is necessitated by available information, but may not be accurate. It is clear from the CCCS data that concentration can vary substantially on a daily basis; the difference between the highest and lowest measured chloride concentration was about a factor of 2 in most locations. The difference did not appear to correspond to seasonal changes, in-stream flow volume, location, or other easily observed factors. It is possible that changes on daily, seasonal, or long-term time scales could produce impaired conditions that are not reflected in the available data. Since agricultural irrigation is the beneficial use to be protected, daily fluctuations may not be critical, because it is believed that crop productivity is affected by exposure to chloride over the life of the crop rather than acute exposure to the highest concentration on any day in the life of the crop. Stakeholders may wish to do more comprehensive monitoring to verify the assumption. Although the data do not provide a perfect understanding of variability of chloride concentration, they are the best available for recent conditions, so the assumption is necessary.

The model was developed using data for “typical low-flow” conditions, defined in Section 4 above. Tables A-1A, A-1B, and A-1C, in Appendix A, summarize the input parameters (flow volume and chloride concentration) for average or typical low-flow conditions used to construct the model.

The best available data were used to estimate volume and chloride concentration of inflows and outflows to each under similar conditions. In most cases, the best estimate was assumed to be the average of available measurements, excluding in some cases “outlier” measurements taken on non-typical days. Data were evaluated for flow volume and chloride concentrations for inflows and outflows including agricultural withdrawals, groundwater recharge and discharge, and POTW discharges. The tables document the best available data, giving references for the data used to develop or estimate the parameters. The tables also describe the rationale for any choices necessary to adjust the model to computationally duplicate measured in-stream conditions. In evaluating critical conditions, the inflow and outflow conditions were modified to reflect conditions during those periods, with reported data where available and with assumptions where necessary about expected impacts from critical conditions on flow and concentrations. Table A-2 describes the rationale for calculations, estimates, and assumptions used to model for other conditions, in particular the factors used to translate available data from average or typical conditions to the critical conditions of interest.

7C. LINKAGE ANALYSIS RESULTS

The linkage analysis results are presented in two sections. Section 7C1 presents model results using current conditions of discharges and stream flows. Those results help evaluate the degree of impairment under a range of conditions, by calculating in-stream concentration at various locations under conditions of low flow; maximum non-storm flow; drought; and the immediate post-drought period. Section 7C2 duplicates those analyses for anticipated future conditions (but in the absence of remedies required under this TMDL). The most crucial anticipated future change is a planned diversion of flow from Reach 9, the Conejo Creek main stem, which would substantially affect the concentration of chloride in that reach and downstream reaches if some remedy were not implemented.

7C1. Current Conditions

Figure 8 graphs chloride concentration results of the mass balance model for six potentially critical flow conditions, all drawn from current conditions. Results are graphed for five locations in the Calleguas Creek system, including the three USGS gauging stations. Model results can be used to calculate LAs and WLAs designed to reduce chloride concentration to below the numeric target, and thus remove the impairment. The six conditions are: storm flow;

three kinds of non-storm flow (low flow, typical or average flow, and maximum non-storm flow); and two kinds of drought related conditions (drought and immediate post-drought periods).

Storm flow conditions are included to demonstrate the lack of impairment. Figure 8 clearly shows lower chloride concentration during conditions assumed for storm flow. The expected in-stream concentration is less than 65 mg/L at all modeled locations during storm discharge.

Concentration is greatest under the influence of a drought, especially during the immediate post-drought period. Under the assumed loading and flow conditions described above, non-point flows are small. The POTW point sources were assumed to discharge chloride under drought conditions at 20% greater concentration than the 1999 average. The model predicts surface waters will not exceed the WQO in the northern part of the watershed. The model predicts the concentration in Reach 3 would be approximately 160 mg/L, so the designated beneficial use would be impaired in Reach 3 during drought conditions.

Concentration is predicted to be greater during post-drought conditions than during a drought. After the drought ends, when groundwater discharges resume with the rising water table but after having continued to receive chloride loads throughout the drought, the model assumes the concentration of chloride in groundwater discharges remains for a time at the drought concentration level of 20% greater than the typical conditions as reported in current data. Under those assumptions, in-stream concentration would be about 150 mg/L in Reaches 9 and 10 without the margin of safety. Concentration would be 160 mg/L at the downstream of Reach 9, at the Conejo/Calleguas confluence; and would be 186 mg/L in Reach 3, or 24% greater than the WQO of 150 mg/L. In the northern reaches, post-drought concentration in Reach 7 below the Simi Valley POTW is predicted to be 148 mg/L.

The remaining three conditions are variations of non-storm conditions, which constitute 80% or more of the days in a typical, non-drought year. The conditions, defined using historical data from USGS for the three gauging stations, are: low flow, defined as the smallest in-stream flow observed over a period of 7 days with a 10-year recurrence interval; typical flow, defined as the 50th percentile flow during the period of record; and maximum non-storm flow, defined statistically as described in Section 4C3 above. As Figure 8 shows, of the three non-storm, non-drought conditions, maximum non-storm flow conditions produce the greatest chloride concentration at all locations in the waterbody where the concentration is modeled. Low flow consistently produces the lowest concentration of the three, an expected result since low flow contains none of the nonpoint source loads that are known to contribute to the impairment. The mid-range or “typical” non-storm flow consistently produces a mid-range concentration, higher than during low flow but lower than during maximum non-storm flow.

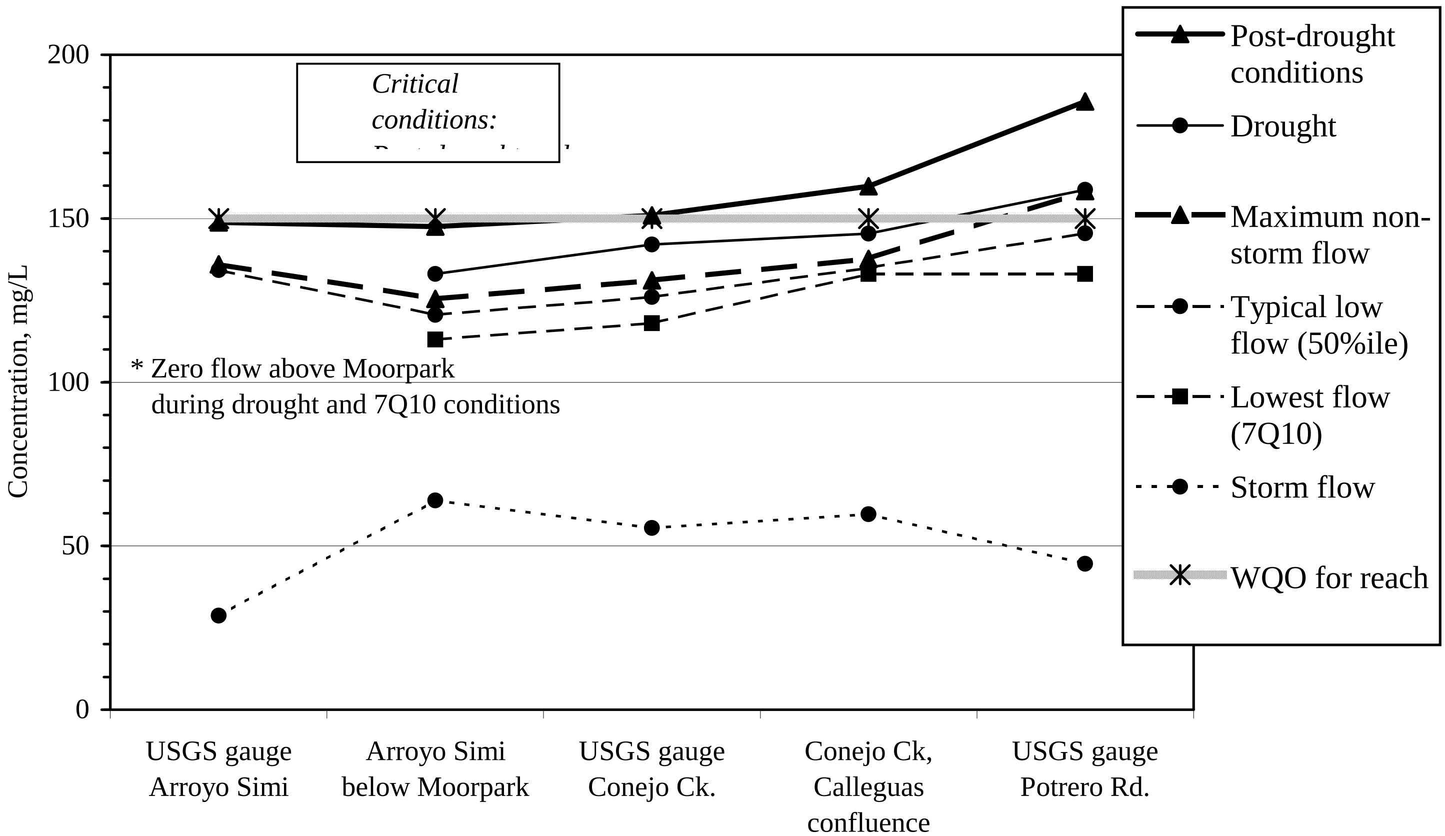
During maximum non-storm flow under current conditions, chloride concentration exceeds WQOs in the northern reaches and the Calleguas Creek main stem, but not in the southern tributaries. At the Conejo/Calleguas confluence, concentration is predicted as 138 mg/L, below the WQO of 150 mg/L; but at the Potrero Road gauge, concentration is predicted at 158 mg/L, or 5% greater than the WQO. The increased concentration in that reach is attributable to agricultural drainage and groundwater discharge, including the area influenced by discharge to groundwater from the Camrosa POTW.

The calculations based on the current conditions are not tabulated in the appendix because the conditions are not used to calculate the TMDL. Instead, the diversion scenario (Section 7C2) which is currently under construction, is the basis of the TMDL.

7C2. Future Conditions: The Effect of the Reach 9A Diversion

LAs and WLAs need to be calculated using not current conditions but expected future

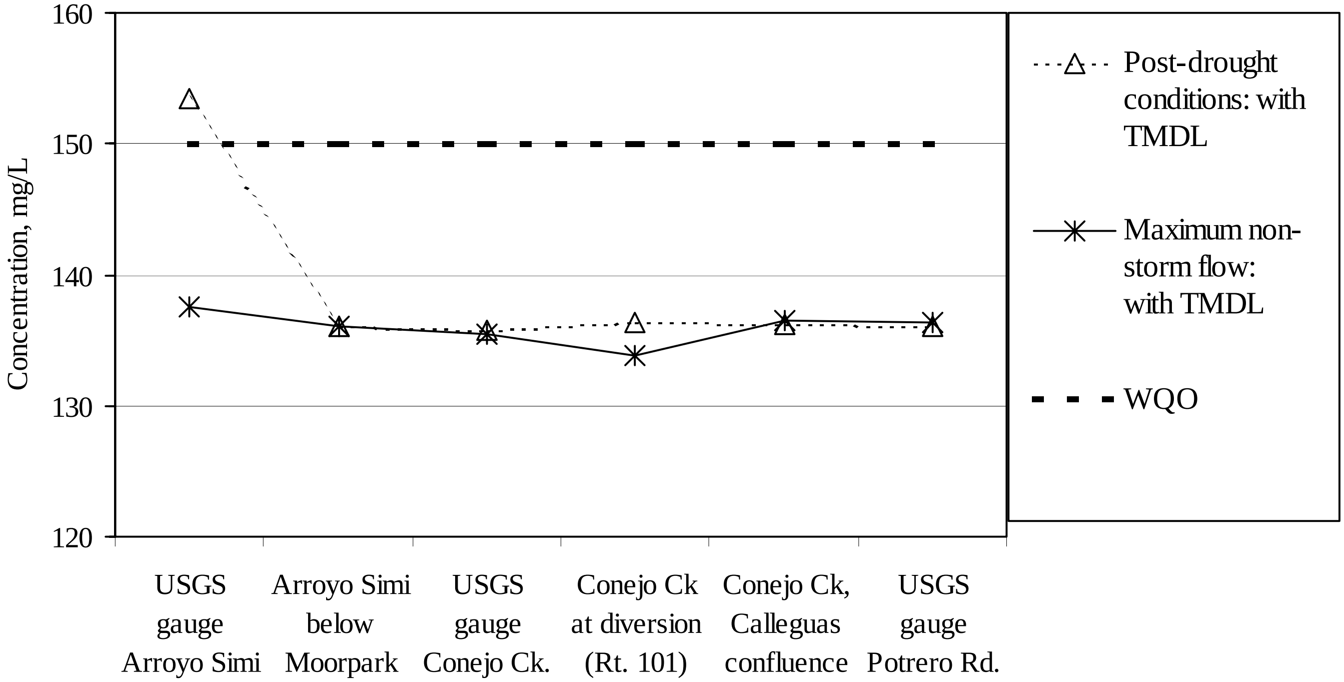
Figure 8. Linkage Analysis Model Results: Chloride Concentration under Various Flow Conditions, Selected Locations. Current Conditions (without Reach 9B Diversion).



conditions, including the effect of the intended Reach 9A diversion. The diversion will affect in-stream flow, and chloride concentration, in Reaches 3 and 9 only. Figure 9 shows the predicted in-stream chloride concentrations after the TMDL implementation at the designated monitoring points. The in-stream chloride target will be met for both routine and drought/post drought conditions other than at USGS gauge Arroyo Simi (in the middle of Reach 7). This is not considered as a violation of protection of designated use since Reach 7 is only designated as intermittent GWR use and the WQO of 150 mg/L is intended to protect more sensitive AGR use.

The downstream portion of Reach 7, where potential AGR use occurs, is predicted to meet the numeric target of 136 mg/L even during the most critical period, under post-drought conditions.

Figure 9. Linkage Analysis Model Results: Predicted In-Stream Chloride Concentration After TMDL Implementation under Two Critical Conditions, Selected Locations (With Reach 9B Diversion)



The modeling suggests that the chloride concentration at the first monitoring point (Reach 7 Arroyo Simi-USGS gauge) may slightly exceed the 150 mg/L standard during the drought/post-drought condition (predicted concentration of 154 mg/L). We note that this monitoring point is not in an area designated for AGR use, and that in the area downstream where AGR is in fact designated as a potential use, the modeled results indicate that concentrations will be well below the 150 mg/L WQO, as evidenced by the results for the second monitoring point (Arroyo Simi below Moorpark, near confluence of Reaches 7 and 6). Given the closeness of the modeled number to the water quality objective, the clear results indicating that the objective will be met at all the other monitoring points (and at all six points under the routine critical condition), and the absence of the AGR use in Reach 7, we would conclude that, in our best professional judgment, it is reasonable to assume that implementation of this TMDL should result in meeting the water quality objective at the watershed level and that, at this time, it is not necessary to recalculate the allocations at lower levels.

For comparison, the concentrations that would be attained with the diversion in place but in the absence of the TMDL are computed in Table A-3, in the Appendix. The projected chloride concentration is computed at the locations in the waterbody where flow information is sufficient to support the model. The table includes calculations for the two critical conditions, maximum non-storm flow and the immediate post-drought period; and also for conditions of drought, typical low flow, and storm discharge. With the diversion in place, under the maximum non-storm flow conditions the modeled chloride concentration at the Potrero Road station in Reach 3 would be about 184 mg/L, exceeding the WQO of 150 mg/L by 23%. That concentration is attained in that reach at present only under post-drought conditions, the long-term worst-case conditions; with the diversion in place, the same concentration may be reached on any day of the year when groundwater discharges are at their maximum and no storm runoff is present for dilution. Under maximum non-storm conditions, the WQO is not exceeded in the southern tributaries, only in the Calleguas Creek main stem. However, much of the load to the main stem originates with the southern tributaries, so remedies may need to address dischargers in those reaches. The above calculation assumes that the pumped groundwater upstream from the USGS gauge Arroyo Simi will be piped to the Simi Valley POTW for treatment during the drought/post drought condition.

8. ALLOCATION OF LOADS AND WASTE LOADS

This section uses the results of the linkage analysis in Section 7C above to develop proposed load allocations (LAs) for loads from natural background sources and other nonpoint sources, and waste load allocations (WLAs) for currently permitted point source discharges. The proposed LAs and WLAs are calculated such that WQOs will be attained in all parts of the waterbody. Calculated LAs and WLAs use results of the linkage analysis in the previous section, and incorporating a margin of safety. LAs and WLAs are proposed for two conditions. One set of LAs and WLAs are proposed for routine days, defined as all non-storm, non-drought days, and are calculated based on the critical condition of maximum non-storm flow. The other set of LAs and WLAs are proposed for drought conditions, and are calculated based on the critical condition of the immediate post-drought period. Both sets of LA s and WLAs are calculated assuming the Reach 9B diversion will reduce in-stream flow in that reach to 6 ft^3/sec under all conditions.

8A. MARGIN OF SAFETY

A number of measured and estimated parameters in this TMDL have some degree of uncertainty. Therefore LAs and WLAs proposed in this section incorporate both an implicit and an explicit margin of safety. The margin of safety is intended to ensure the waterbody will not exceed the WQO, and the impairment will be removed, under WLAs specified by this TMDL.

The implicit margin of safety is applied by calculating LAs and WLAs for all days using the worst-case conditions. The linkage analysis above shows that worst-case chloride concentration occurs on days when in-stream flow reaches its maximum, other than days affected by storm runoff. That maximum non-storm flow may occur in any season and under circumstances that cannot be reliably forecast, so the LAs and WLAs need to be set at a level that can accommodate those conditions in case they should occur. This assumption produces a margin of safety because the worst-case conditions do not in fact occur on every day not affected by storm runoff, so on most days of a given year the LAs and WLAs are conservative. Use of the worst-case conditions as an implicit margin of safety is reasonable because the waterbody's assimilative capacity for chloride is so strongly dependent on in-stream flow, which varies both for reasons that have been documented (such as seasonality and precipitation events) and for other reasons less well understood.

The explicit margin of safety is applied by using the model to compute LAs and WLAs that would reach a target in-stream chloride concentration that could be underestimated by 10% and still attain the WQO for each reach. Setting WLAs using a target concentration 10% less than the WQO preserves an unallocated assimilative capacity, or in other words reserves a certain portion of the stream's assimilative capacity to accommodate the uncertain loads. This results in a numeric target concentration of 136 mg/L in Reaches 3 through 13 except at one modeling point. The modeling suggests that the chloride concentration at the first monitoring point (Reach 7 Arroyo Simi-USGS gauge) may slightly exceed the 150 mg/L standard during the drought/post-drought condition (predicted concentration of 154 mg/L). We note that this monitoring point is not in an area designated for AGR use, and that in the area downstream where AGR is in fact designated as a potential use, the modeled results indicate that concentrations will be well below the 150 mg/L standard, as evidenced by the results for the second monitoring point (Arroyo Simi below Moorpark, near confluence of Reaches 7 and 6). Given the closeness of the modeled number to the water quality objective, the clear results indicating that the objective will be met at all the other monitoring points (and at all six points under the routine critical condition), and the absence of the AGR use in Reach 7, we would conclude that, in our best professional judgment, it is reasonable to assume that implementation of this TMDL should result in meeting the water quality objective at the watershed level and that, at this time, it is not necessary to recalculate the allocations at lower levels.

Applying an explicit margin of safety, in addition to the implicit margin of safety, is reasonable because many of the chloride loads in the watershed are not precisely quantifiable with the data available, and the linkage analysis has been completed using estimates whose precision is not known. A number of uncertain estimates are accommodated by the explicit margin of safety. In particular, the estimated existing loads from groundwater and other non-point sources are quite uncertain. For example, the chloride concentration in groundwater-dominated reaches as measured by the CCCS vary by a factor of 2 or 3 over the course of one year. Loads for natural groundwater discharges in several parts of the waterbody have been estimated based on a small number of in-stream flow and concentration measurements, along with assumptions apportioning the calculated loads among a variety of sources. Similarly, loads for pumped groundwater discharges include assumptions and estimates about chloride concentration, although flow can be more readily measured and controlled through discharge permits. Other sources of imprecision may also be present in the calculations.

8B. SUMMARY OF LAs AND WLAs BY REACH

This section summarizes the proposed WLAs for major discharges and aggregated WLAs for minor discharges, and LAs for non-point sources. Tables included here describe WLAs and LAs for both routine conditions and drought conditions. The proposed allocations are selected such that the modeled in-stream chloride concentration does not exceed the numeric targets for any reach of the waterbody during critical conditions, including an explicit margin of safety. Table A-4, in Appendix A, presents calculations demonstrating that WQOs are attained with these WLAs under critical conditions. The tables in this section are summaries of the calculations presented in Table A-4.

8B1. Allocations for Routine Conditions

Table 2 summarizes LAs and WLAs under routine conditions. Those conditions are assumed to exist on any day of the year that is not influenced either by storm flow or by drought conditions (defined in the next paragraph). WLAs and LAs for routine conditions are calculated based on conditions during maximum non-storm flow. Those conditions are assumed to apply on routine days because days of maximum non-storm flow can occur at any season of the year, and cannot be reliably predicted or identified by dischargers sufficiently far in advance to adjust effluent conditions. Any given day when flow is not diluted by storm runoff could attain that worst-case, critical condition.

8B2. Allocations for Drought Conditions

Table 2 summarizes LAs and WLAs for major dischargers under drought conditions. The proposed allocations are selected such that the modeled in-stream chloride concentration does not exceed the WQOs for any reach of the waterbody during drought conditions, including an explicit margin of safety. Allocations for the drought condition are more rigorous than those specified for everyday critical conditions, based on the linkage analysis results that show waterbody chloride concentration is substantially greater during drought conditions and in the period immediately following a drought.

8B3. Definition of Drought for This TMDL

The more stringent WLAs which apply during drought periods are intended to compensate for the increased concentrating effect of a drought, and for the post-drought period when that more-concentrated groundwater again begins to enter the waterbody. That length of time is intended to encompass the immediate post-drought period, when the linkage analysis shows in-stream chloride concentration at many parts of the waterbody is even greater than during drought conditions. This TMDL specifies WLAs for the entire period based on post-drought conditions, even if conditions may not be as critical during the drought as anticipated during the post-drought period. That is because the chloride may be expected to be concentrated by agricultural activities from the start of the drought until the drought ends. That concentrating process will have begun at least one wet-weather season prior to the drought's being observed and the drought-period WLAs taking effect, so the more stringent WLAs are justified in order to compensate for the chloride buildup during that period.

Drought conditions are defined in multiple ways for different purposes. The National Drought Mitigation Center (1995) identifies six categories for definitions of drought: conceptual; operational; meteorological; hydrological; agricultural; and socioeconomic. The State of California Department of Water Resources (DWR) drought report (2000) uses an operational definition, defining drought as a period with "runoff for a single year or multiple years in the lowest ten percent of the historical range and reservoir storage for the same time period at less than 70 percent of average."

The conditions under which drought affect the WLAs and LAs for the Calleguas Creek watershed argue for a local rather than a statewide definition, and for a hydrological or meteorological definition rather than operational, agricultural, or socioeconomic. That is because the drought condition increases impairment when chloride concentration in the shallow groundwater begins to increase to a much greater degree than under a typical year (a result of less than normal rainfall, which decreases the mechanisms of leaching chloride from the root zone and flushing higher-concentration water from the aquifer). During the drought period, agricultural irrigation and other activities continue to add load to the aquifers but discharge from the aquifer ceases and chloride builds up in the subsurface.

Conversely, a statewide definition may be desirable from the viewpoint of increases in chloride load in imported water, because chloride concentration in imported water increases when the supplying watershed undergoes a drought. That condition may occur when a drought occurs in any of the major watersheds that supply water to the waterbodies used by the State Water Project to move water to southern California which may be used by Calleguas Creek watershed water suppliers. Regional Board staff opts for a local rather than a statewide definition in order to avoid the complexity of defining multiple possible triggering events, such as low rainfall in any of several key watersheds in the state that could cause high chloride concentrations in imported water. The local definition is a reasonable surrogate for a statewide definition, or definitions local to multiple supplying watersheds, because a statewide drought in California is likely to be accompanied by drought conditions in the Calleguas Creek watershed. Therefore the triggering mechanism proposed here is likely to capture periods of statewide drought that will affect chloride load in imported water supplies.

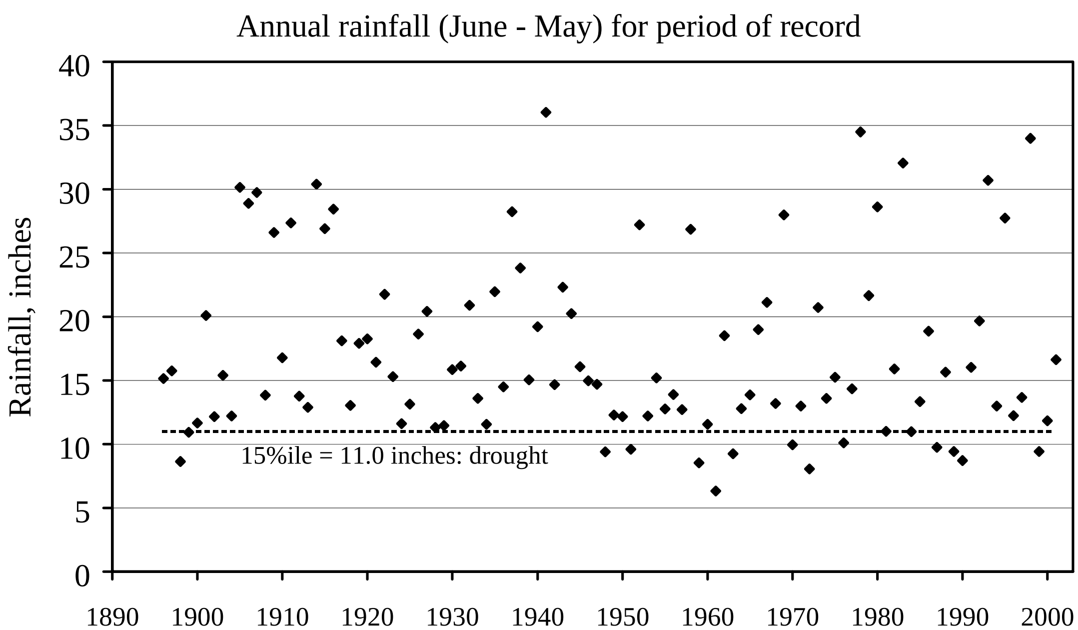
This TMDL adopts a meteorological definition of drought for purposes of demarking a period when the drought-defined WLAs are to take effect. The drought-period WLAs will be in effect beginning on June 1 of any year when the previous twelve months' total rainfall is less than the lower 15% of the historical range. That definition uses the same procedure as the hydrological portion of the DWR's operational definition, which states a condition of runoff in the lower 10% of the historical record. The choice of the lower 15% of the historical record is appropriate because the changes in groundwater concentration and discharge conditions, upon which the drought-period LAs and WLAs are based, may be expected to occur at a slightly less severe condition than the economic effects upon which the DWR operational definition is based. The date of calculation is specified as June 1 because the annual patterns of rainfall in the Calleguas Creek watershed are such that in nearly all years, nearly 100% of precipitation for the wet-weather year occurs before the month of May.

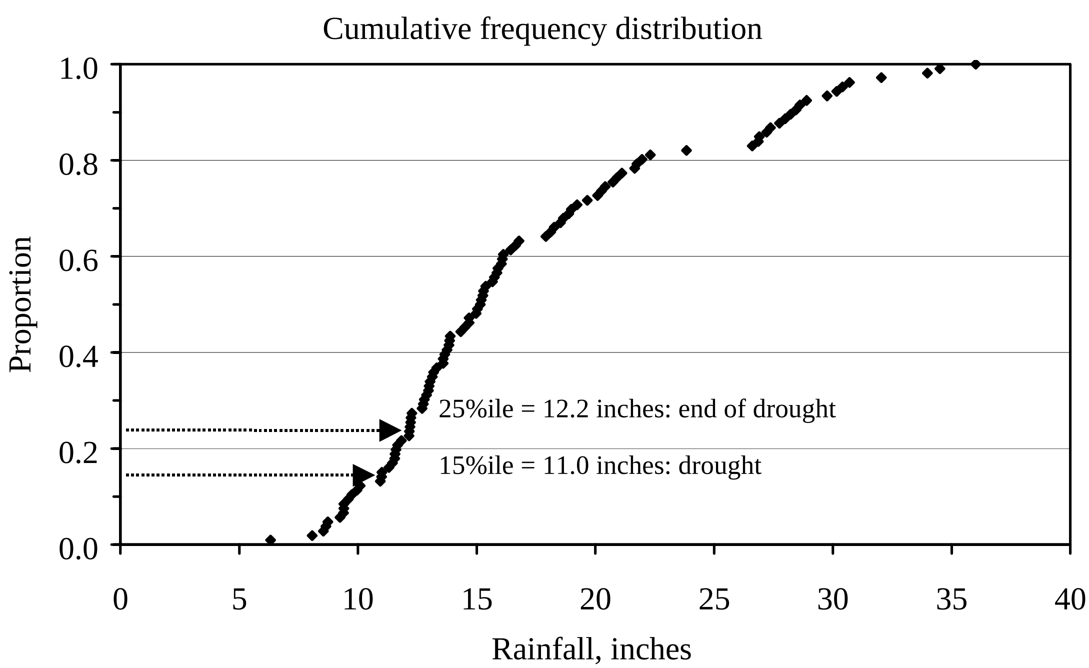
The drought-period WLAs are to remain in effect until the first June 1 on which the previous twelve months' total rainfall equals or exceeds the lower 25% of the historical record. The drought-period year is defined as ending on May 31 of the first year in which the total rainfall over a twelve-month period has been at least the 25% of the historical range. As Figure 10 shows, that rainfall amount is calculated to be 12.2 inches per year.

Figure 10 demonstrates the calculations for beginning and ending of drought periods as defined for this TMDL. Figure 10 uses monthly rainfall data reported by the National Weather Service (NWS) for California Zone 6 (Coastal Southern California), grouped into twelve-month periods from June 1 through May 31. The upper graph in Figure 10 uses the NWS data to show historical rainfall patterns, with total annual rainfall calculated on June 1 of each year. Drought-period years can be identified as those data points lower than the 11-inch line, shown in bold on the graph. The lower graph in Figure 10 graphs the same data in a cumulative frequency plot, which was used to identify the 15%^{ile} and 25%^{ile} points. Those points are marked with arrows on the plot.

The 15%^{ile} point of all years with available data (1895 through 2001), with years defined as June 1 – May 31, is 11.0 inches per year. The 25%^{ile} point of those same data is 12.2 inches per year. Therefore drought-period WLAs are specified to be in effect beginning on June 1 of any year in which the previous 12 months' total rainfall at the Camarillo Airport is less than 11.0 inches, and continuing until the first June 1 on which the previous 12 months' total rainfall at the Camarillo Airport is at least 12.2 inches. The data of record for this determination is specified to be the National Weather Service monthly rainfall for California Zone 6, Coastal Southern California. Monthly total rainfall may be obtained from the National Weather Service web site for Southern California Climate Archives, http://nimbo.wrh.noaa.gov/sandiego/climate.html.

Figure 10. Annual Rainfall 1895-2001 (June-May), National Weather Service Data for California Zone 6, with Definition of Drought for This TMDL.





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10. GLOSSARY

Assimilative Capacity. The greatest amount of loading that a water can receive without violating water quality standards. Also called *loading capacity.*

Best Management Practices. Methods, measures, or practices selected by an agency to meet its nonpoint source control needs. BMPs include but are not limited to structural and nonstructural controls and operation and maintenance procedures. BMPs can be applied before, during, or after pollution-producing activities to reduce or eliminate the introduction of pollutants into receiving waters.

Continuing Planning Process. Required by Clean Water Act §303(e) and 40 CFR 130.5. States must submit for EPA's review and approval a continuing planning process. The process must include procedures for development and updating of plans for effluent limits, waste management plans, basin plans, TMDLs, procedures for revision, and demonstration of adequate authority for implementation.

Clean Water Act. The Federal Water Pollution Control Act, 33 USC § 1251 et. seq.

Coastal Zone Amendments Reauthorization Act of l 990. Requires states with approved coastal zone management programs to develop a coastal nonpoint source pollution control program.

Effluent Limitation. Any restriction established by a state or the EPA on quantities, rates, and concentrations of chemical, physical, biological, and other pollutants that are discharged from point sources into water bodies.

Federal Advisory Committee on the TMDL Program. Established in 1996 by the EPA. The Committee was charged with recommending ways to improve the TMDL programs required by Clean Water Act §303(d). The committee was a subdivision of the National Advisory Council for Environmental Policy and Technology (NACEPT) and was established under the authority of the Federal Advisory Committee Act.

Load or Loading. An amount of matter that is introduced into a receiving water. Loading may be either human-caused (pollutant loading) or natural (natural background loading).

Load Allocation (LA). The portion of a receiving water's loading capacity that is attributed to one of its existing or future nonpoint sources of pollution or to natural background sources.

Loading Capacity. The greatest amount of loading that a water can receive without violating water quality standards. Also called *assimilative capacity.*

National Pollutant Discharge Elimination System (NPDES). The wastewater discharge permit system established by the Clean Water Act. Permits regulate the discharge of wastewater from municipal and industrial point sources, as well as certain concentrated animal feeding operations. More than 200,000 sources are regulated by NPDES permits nationwide.

Nonpoint Source Pollution. Pollution that is not discharged from a point source. It is usually caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters, and even underground sources of drinking water.

Point Source. Any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. As defined in the Clean Water Act, this term does not include agricultural stormwater discharges and return flows from irrigated agriculture.

Publicly Owned Treatment Works (POTWs). Any device or system used in the treatment (including recycling and reclamation) of liquid municipal sewage or industrial wastes which is owned by a state or municipality.

Regional Water Quality Control Boards (RWQCBs). The governing bodies of the nine water quality control regions in California. Each Board consists of nine members appointed by the Governor. The regional boards act to protect water quality by adopting region-specific water quality control plans, called Basin Plans. The Basin Plans contain water quality standards that are specific to surface waters and groundwater within a particular region or portion thereof. The Basin Plans are implemented through the issuance of waste discharge requirements, or permits.

State Water Resources Control Board (SWRCB). The state agency responsible for protecting water quality in California under the Porter-Cologne Act. The Board consists of five full-time salaried members, appointed to four-year terms by the Governor. The Board adopts enforceable policies for water quality control and regulations to protect water quality from discharges of waste to water or to land where water quality could be adversely affected. Together, the State Water Board and the Regional Boards carry out a comprehensive program for managing water quality in California, as well as for effective state administration of federal water pollution control laws.

Storm Water Permits. NPDES permits for storm water systems that are separate from wastewater treatment systems. Permits are required for storm water systems serving communities with more than 100,000 inhabitants, and for storm water discharges associated with industrial and construction activity involving at least five acres. In the future, smaller urban areas, construction sites, and retail and commercial activities will be covered by the permit requirements.

Total Maximum Daily Load (TMDL). A quantitative assessment of water quality problems, contributing sources, and load reductions or control actions needed to restore and protect individual water bodies. The TMDL is the sum of the load allocations for nonpoint sources and natural background pollutants, the waste load allocations for point sources, and a margin of safety.

Waste Discharge Requirements (WDRs). Requirements as to the nature of any proposed discharge, existing discharge, or material change in an existing discharge with relation to the conditions existing in the disposal area or receiving waters upon or into which the discharge is made or proposed. The requirements shall implement any relevant water quality control plans that have been adopted, and shall take into consideration the beneficial uses to be protected, the water quality objectives reasonably required for that purpose, other waste discharges, the need to prevent nuisance, and the water quality objectives established under Water Code Section 13241.

Water Quality Limited Segments (WQLS). Those water bodies or parts of water bodies that do not meet water quality standards after applying technology-based effluent limitations required by the Clean Water Act.

Water Quality Standards. Provisions of state or federal law that consist of a designated use or uses for the waters and water quality criteria for such waters based upon such uses.

Water Quality Management Plan. Required by Clean Water Act §§205(j), 208, and 303(e). Includes a state or area-wide waste treatment management plan developed and updated in accordance with the provisions of the Clean Water Act and associated regulations. California's water quality management plan consists of a series of statewide plans adopted by the State Water Resources Control Board, and a basin plan adopted by each of the nine Regional Water Quality Control Boards.

Watershed. Natural boundaries delineating the areas that drain to water bodies, including lakes, rivers, estuaries, wetlands, streams, and the surrounding landscape.

Waste Load Allocation. The portion of a receiving water's loading capacity that is allocated to one of its existing or future point sources of pollution.

Many glossary items are courtesy of the California Research Bureau, from *TMDLs: The Revolution in Water Quality* (Jennifer Ruffalo, 1999), California State Library report CRB-99-005.

11. LIST OF ACRONYMS

BMP Best Management Practices

CPP Continuous Planning Process

CWA Clean Water Act

CZARA Coastal Zone Amendments Reauthorization Act of 1990

FACA Federal Advisory Committee Act

LA Load Allocations

NPDES National Pollutant Discharge Elimination System

POTW Publicly Owned Treatment Works

RWQCB Regional Water Quality Control Board

SWRCB State Water Resources Control Board

TMDL Total Maximum Daily Load

WDRs Waste Discharge Requirements

WLA Waste Load Allocation

WMI Watershed Management Initiative

WQLS Water Quality Limited Segments

APPENDIX A: DATA, ESTIMATES, AND ASSUMPTIONS FOR LINKAGE ANALYSIS

This Appendix describes methods and information used for analyses in this document, especially for the Linkage Analysis that relates observed in-stream ambient conditions to information about discharges and sources of chloride. The Appendix describes data relied upon about water quality and water quantity in the Calleguas Creek watershed; assumptions about discharges and sources, where data were not sufficiently detailed to completely characterize the human activities or the environmental systems; and methods used to make estimates using the data and the assumptions. The text of this Appendix is structured as a description of the detailed tables.

The tables and accompanying text describe available data from all sources available to the Regional Board, the sources of those data, and the interpretation of the data where that interpretation was not clear and straightforward. In some cases available data were not sufficiently complete to conduct all necessary analyses, for example about water quality and quantity at particular locations in the watershed. In those cases, Regional Board staff made estimates and assumptions. The estimates applied best professional methods, and were derived from a variety of sources including available data on similar environmental systems; information from stakeholders and others in the watershed; information from professional manuals of practice and guidelines from U.S. EPA; and best professional judgment of the Regional Board staff. The tables and text of Appendix A describe the basis for those estimates and assumptions, along with descriptions of available data and their limitations, so that readers of this Staff Report may readily identify the rationale behind the estimates and assumptions. That rationale may be used to improve estimates as additional information becomes available, or to calculate different estimates with different underlying assumptions should improved assumptions become available.

USE OF FLOW DATA TO DETERMINE MAXIMUM NON-STORM FLOW

Figure A-1 presents three pairs of graphs for historical in-stream flow (one for each of three locations in the waterbody), used in the analysis of flow data in Section 4 of the Technical Support Document to select the “maximum non-storm flow.” All graphs use data from the period determined to be representative of current conditions (called “recent period” in Section 4). The three locations are the points measured by USGS gauges in three parts of the waterbody: Arroyo Simi, at Madera Road; Conejo Creek at the Highway 101 overpass; and Calleguas Creek at Potrero Road. Each graph uses USGS data on mean daily discharge (mdd), quantified throughout this Report in units of cubic feet per second, but for this figure converted to liters per second for ease of use in the statistical program used for this analysis.

The goal of the analysis was to identify the flow amount, at each of the three locations, that describes the greatest flow observed under non-storm conditions, in order to separate those days dominated by storm flow (which is not impaired for chloride) from days with all other flow conditions. The graphs represent cumulative frequency distributions; that is, at each location, each measured mdd (located across the x axis) is plotted against the number of times it was observed during the period of record. The graphs use a normal probability plot on the y axis; that is, the scale is symmetrical about 50%, and logarithmic in each direction from the 50% point.

The graph uses that normal probability plotting method in order to test the normality of the distribution. If the data follow a straight line in such a plot, the data are normally distributed, which would allow use of certain statistical analyses that would be inappropriate if the data are not normally distributed. The straightness of the line is indicated by the correlation coefficient R marked on each graph: the more nearly R approaches 1.0, the more nearly the data are normally distributed.

Because it is routine for environmental data to follow a log-normal distribution, rather than a normal distribution, the first tests assumed these flow data to be log-normally distributed. For that reason, the frequency in the left-hand graph of each of the three pairs uses a natural-log transformation; that is, the x axis plots not the mdd in L/s, but the natural log of the mdd (labeled "ln of mdd, L/s). Those graphs are in the column labeled "normality test for log-transform."

The three left-hand graphs show a marked visual pattern. The data points to the right of the bend (above the dashed arrow) follow a reasonably straight line. In that neighborhood, the data are nearly log-normally distributed. However, to the left and below the bend or the dashed arrow, the data do not follow a straight line. The correlation coefficient R in those three graphs is not very near to 1.0, but instead is between 0.80 and 0.87, largely because of the significant curvature marked by the visible bend. The sharp change in slope at the bend of each graph indicates some statistical change in the data between the lower and the upper part.

The nature of that change is explained in the right-hand graphs, labeled "normality test for trimmed data." All three graphs plot only those data points below the sharp curve in the left-hand graphs, and in all three cases use the mdd data directly, without the log-transform (x axes are labeled "mdd, L/s"). All three cases are very good approximations of a straight line, with correlation coefficients R of greater than 0.97 in the Conejo Creek data and greater than 0.99 in the data for the other two locations. The point of transition is especially clear in the Simi Valley data, where the dashed arrow corresponds to the bend in the curve. The transition is less clear in Conejo Creek, and even less so in Calleguas Creek, probably because both points are further downstream in the watershed and a greater number and variety of upstream discharges affect the in-stream flows. The transition point is chosen at about the 80th percentile for both points, a reasonable interpretation of the data, but other choices may be possible. The left-hand graph for Calleguas Creek illustrates the range of possible choices, with dashed arrows placed at both the 75th and 90th percentile points. The right-hand graph shows an extremely good fit for the 80th percentile at the Calleguas Creek location, so selecting the 80th percentile as the transition point is a reasonably conservative interpretation of the data. The Conejo Creek data do not achieve quite so complete a fit at the 80th percentile as do the other two locations, but Staff conclude the 80th percentile produces a reasonably good fit at R = 0.979.

Each location's left-hand and right-hand graph, taken together, indicate a point where the flow data's distribution shifts from normally distributed (to the left and below the sharp curve) to log-normally distributed (to the right and above the curve). The normally distributed data constitute 85% of all mdds in Arroyo Simi, and about 80% of all mdds in Conejo Creek and Calleguas Creek. All mdds measured above those points are log-normally distributed. It is reasonable to assume this clear shift in the data corresponds to the shift of in-stream flows from non-storm conditions to storm conditions. That is reasonable because during non-storm conditions, flow originates primarily from two sources, POTW discharges and groundwater discharges, plus a variety of smaller sources including groundwater pumped for treatment or dewatering and miscellaneous urban runoff such as lawn watering and washing of buildings and vehicles. It is reasonable to expect those flows to be normally distributed. The flows during storm conditions may be expected to be log-normally distributed, following guidance from USEPA and others that suggests in-stream flows from natural discharges are log-normally distributed.

The point on the cumulative frequency graphs at which flow changes from normally distributed to log-normally distributed is assumed to be the point of maximum non-storm discharge. That is, the point marked by the dashed arrows is the greatest flow observed at those three locations before the data shift to a log-normal distribution, which is characteristic of storm flows. Those mean daily discharges correspond to about 140 L/s (5 ft^3/s) at the Arroyo Simi gauging station; about 650 L/s (23 ft^3/s) at Conejo Creek; and about 910 L/s (32 ft^3/s) at Calleguas Creek gauging station. The flows calculated in this fashion for Arroyo Simi and Calleguas Creek are used throughout this document to describe maximum non-storm flow for those locations. The maximum non-storm flow used in the document for the Conejo Creek location has been adjusted downward slightly to 20 ft^3/s. That adjustment both compensates for the slight uncertainty in selecting the point of curvature, and improves the consistency of the flow assumption with other data and assumptions about discharges and withdrawals in that area of the waterbody.

WATER QUALITY AND FLOW DATA FOR LINKAGE ANALYSIS

Table A-1 summarizes the available data and describe the assumptions and best professional judgment used to determine water quality (chloride concentration) in various reaches of the waterbody under various conditions. The water quality information was used in the linkage analysis, which was conducted using Table A-3 below. Table A-1 is divided into three sections. Table A-1A describes the northern portion of the watershed (Reaches 6, 7, and 8); Table A-1B describes the southern portion of the watershed (Reaches 9, 10, 11, 12, and 13); and Tables A-1C describes the parts of the Calleguas Creek main stem considered in this TMDL (Reach 3).

Table A-1 describes the best available data, which were used to determine water quality, along with assumptions about the data's representativity, statistical distribution, and consistency with other known data. Table A-1 lists the raw data and describes how the data were used to estimate water quality under typical conditions (i.e., routine days, or days characterized by typical non-storm flow—neither minimum flow nor maximum non-storm flow, but flow at approximately the 50th percentile of volume identified in the most recent flow data). In cases where data were incomplete or insufficiently detailed for precise calculations, Table A-1 describes the assumptions used by staff to estimate water quality. In cases where separate sources of information provided data that were inconsistent or did not support the same conclusions, Table A-1 describes the rationale used by staff to select between the conflicting data.

The data and water quality determinations in Table A-1 make use of estimates and assumptions to use available data in describing water quality under "typical" flow conditions.The assumed concentrations and flows used in the analysis were selected through a variety of approaches, not always the average of all available data. Averages were used in most cases for chloride concentration data. For the flow rates in the stream channel and for most discharge types, instead of relying on averages either annually or seasonally, other statistical methods were applied as described in Section 4 and in the description of Figure A-1 above. That is because data available from USGS included enough points to make reasonable projections about changes under different conditions. An exception is POTW discharges, where average flow was used in most cases, adjusted for known or anticipated changes in response to drought conditions.

Those analyses use available data for all cases, and rely on those data to the extent possible. For many of the cases, data are limited, and assumptions are necessary. Table A-1 documents the assumptions used for this analysis, based largely on best professional judgment about the relative magnitudes of discharge volume from all dischargers under varying flow conditions, using mass balances analyses of flow volume. The best professional judgments are guided by mass balances by ensuring that the sum of all assumed discharges (and losses) in a given reach or set of reaches is equal to the flow volume measured, or modeled, in the stream at the three locations where flow conditions are defined by USGS gauges. Selection of the flow for each of the three conditions is guided by analysis of recent-period data, as discussed for Figure A-1 above and in Section 4 of the Technical Support Document.

Table A-2 summarizes the assumptions applied in using the water quality for "typical" conditions to determine water quality under other flow conditions of interest, the two critical conditions: maximum non-storm flow; and post-drought conditions. Section 7 of the Technical Support Document describes the choice of these two critical conditions, for use in selecting WLAs and LAs under routine conditions and drought conditions, respectively.

The assumptions described in Table A-2 are considered to be the best available estimates, because more detailed estimates cannot be supported with available data. That is the case even though concentration is known to vary considerably over time and under varying conditions, because the data about chloride concentration do not include sufficient data points to correlate changing concentration with changing conditions at each of the many discharge points and several in-stream measurement points. Ideally concentration data for the linkage analysis would include changes with factors such as season, annual and recent antecedent rainfall, land use and crop type changes, depth to water table, and a wide range of other factors; but in the absence of sufficient data to characterize those relationships, the linkage analysis assumes constant chloride concentration described by averaging available credible data.

LINKAGE ANALYSIS

Table A-3 summarizes results of the calculations that form the linkage analysis. Like the other tables in this Appendix, Table A-3 is divided into three sections: A-3A describes the northern portion of the watershed (Reaches 6, 7, and 8); A-3B describes the southern portion of the watershed (Reaches 9, 10, 11, 12, and 13); and A-3C describes the parts of the Calleguas Creek main stem considered in this TMDL, i.e. Reach 3. Data described in Table A-3 were used in Section 7 to construct the graphs of Figures 9 and 10, which display chloride concentration at selected locations under each of the conditions of interest.

The linkage analysis served two purposes. First, the linkage analysis shown in Table A-3 demonstrates the model replicates observed water quality and flow under "typical" flow conditions, or average non-storm conditions. That is, the parameters described in Table A-1 above were consistent with actual observations; the model structure, assumptions, and input data for typical conditions are consistent best available information about water quality and flow conditions in the waterbody.

Second, the linkage analysis was used to predict water quality and flow conditions under other flow conditions of interest: low flow; maximum non-storm flow; average storm flow; drought conditions; and conditions during the immediate post-drought period. All the chloride concentration and flow data described in the table were calculated using assumptions presented in Tables A-1 and A-2, including based on best available data and on best professional judgment about how chloride loads and volumes of discharges are known or expected to change under changing flow conditions. (In these tables as well as elsewhere in the document, low flow is also called "7Q10" flow, after the USGS method of observing the lowest average flow over any 7-day period within a dataset covering 10 years. The low flow was not determined that way because of a lack of 10 years' data representing current conditions, but instead was calculated as the lowest flow consistent with assumptions about dischargers to the waterbody as described in the linkage analysis using the mass balance model.)

WLA AND LA SPECIFICATIONS

Tables A-4 and A-5 present the calculations of the linkage model used to specify WLAs and LAs for the TMDL for routine conditions and drought conditions, respectively. Table A-4 summarizes calculations for routine days based on critical conditions of maximum non-storm flow. Table A-5 summarizes calculations for drought periods, calculated based on critical conditions of post-drought periods. Like the other tables in this Appendix, Tables A-4 and A-5 are divided into three sections: A-4A and A-5A for the northern portion of the watershed; A-4B and A-5B for the southern portion of the watershed (Reaches 9, 10, 11, 12, and 13); and A-4C and A-5C for the Calleguas Creek main stem.

The two tables use the same model calculations as in Table A-3, with the addition of a set of conditions where chloride loadings to the waterbody are changed to reflect the specified WLAs and LAs. The two tables form the basis for information found in the tables of Section 8 of the Technical Support Document. Tables A-4 and A-5 include the specified WLAs and LAs, which may also be found in the TMDL Staff Report and in the Technical Support Document. In addition, Tables A-4 and A-5 also present the calculation of in-stream chloride concentration under the WLAs and LAs specified for the TMDL. Tables A-4 and A-5 therefore demonstrate that the specified WLAs and LAs are expected to achieve the specified numeric targets, a requirement of the TMDL.

The ambient conditions shown in Tables A-4 and A-5 (flow volume and chloride concentration) are calculated using input conditions of the concentration and flow specified by the TMDL for each of the discharges in the watershed. The calculations incorporate effects in each reach of flow and concentration entering from upstream reaches, as well as effects of chloride loads entering the reaches. Under most conditions (excepting only storm flow conditions), Reach 3 receives flow only from the southern reaches, so the Reach 3 calculations are affected by loads from Reaches 9 through 13, and are unaffected by loads from Reaches 6, 7, and 8.

As stated in Section 8 of the Technical Support Document, the numeric targets for each reach were calculated incorporating an explicit margin of safety in the form of a safety factor applied to in-stream chloride concentration. The concentrations achieved in Tables A-4 and A-5 are 136 mg/L in Reaches 3, 9, 10, 11, 12, and 13 (rather than the specified WQO of 150 mg/L), and 100 mg/L in Reaches 6, 7, and 8 (rather than the specified WQO of 110 mg/L). In both cases, the WQO is equal to 110% of the projected concentrations; that is, the concentrations projected could be exceeded by as much as 10% while still achieving the specified WQO.

Tables A-4 and A-5 were used by staff to identify the WLAs and LAs that would achieve the specified numeric targets at all locations in the waterbody. That is, staff used the spreadsheets to enter proposed LAs and WLAs, and the resulting in-stream concentration was compared to the specified numeric targets to verify that the specified WLAs and LAs met the targets. In effect, the electronic versions of these spreadsheets consisted of the mass balance model, described in Section 7 of the Technical Support Document. The final tables, as reproduced here, demonstrate how the WQOs for each location will be attained under the discharge limits specified in this TMDL, under the assumptions made throughout this document and with the margin of safety specified in Section 8.